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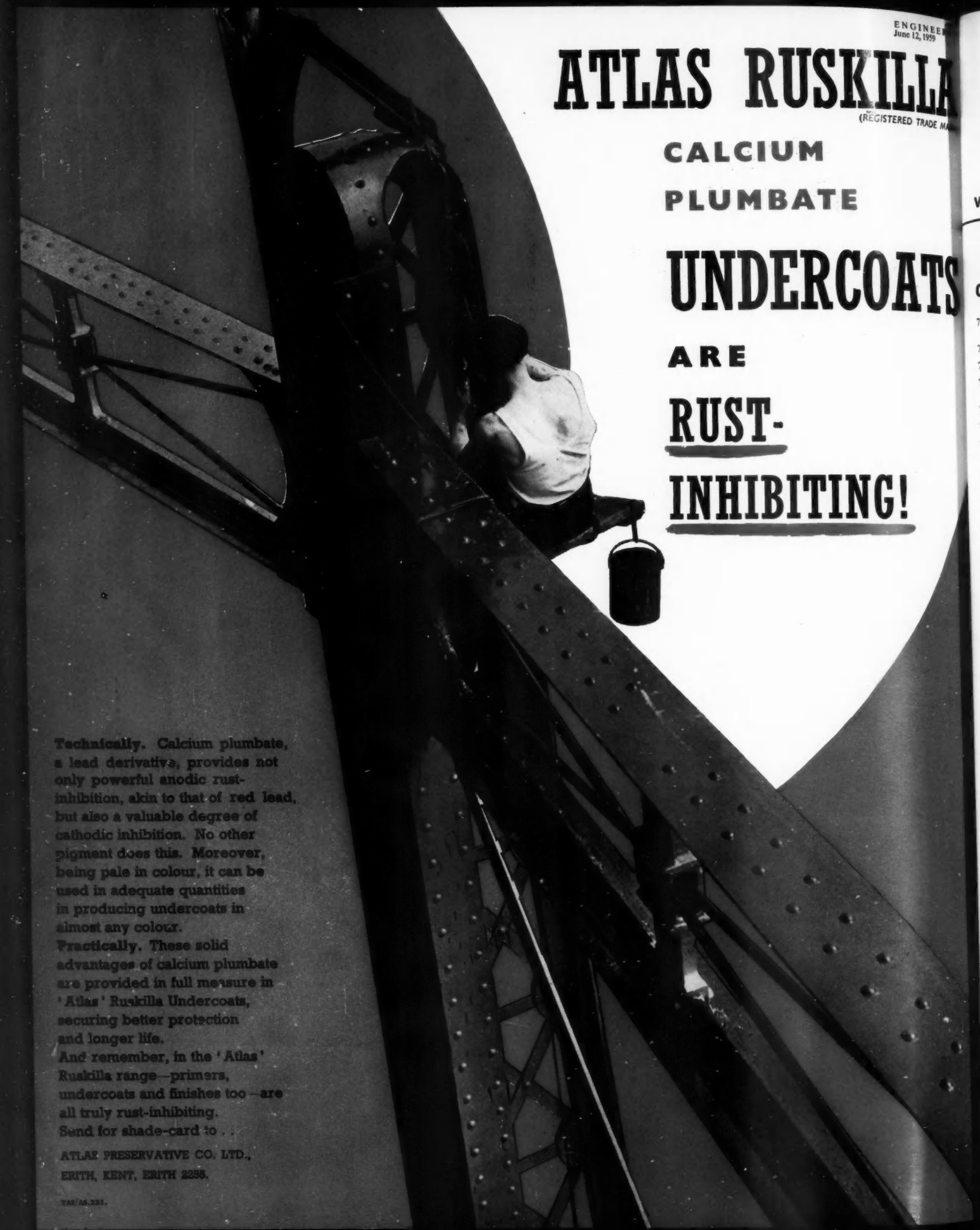

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ENGINEERING

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Tool-Room of the World

SEVERAL times during the past few weeks British firms have secured export contracts for complete production or processing plants. Contracts for individual pieces of machinery are so common as to pass virtually unrecorded, but a complete canning factory is not ordered every day. Yet almost every day a contract has been signed for a plant of that magnitude. If this is a definite trend it is worth watching. Clearly it will be significant to the builders of such plants, but it will also be significant to young engineers and their teachers. For they have to try to look twenty, thirty, even forty years ahead. A complete processing plant demands engineering of the highest order.

Consider the nature of a few of these contracts. One of the largest was secured by Prinex Limited, a subsidiary of Courtaulds. It is worth about £15 million and is for machinery to be exported to the USSR. The machinery includes complete plants for producing viscose rayon tyre cord, acrylic staple fibre and cellulose acetate yarn. Courtaulds had already obtained, last year, a contract to supply Russia with machinery for a textile factory. A consortium of British companies, Rustyfa Limited, have an order worth £14 million to provide Russia with equipment for a new tyre factory. Other orders for Russia include the £1 million contract secured by UD Engineering Company Limited for large-capacity refrigeration plants. Sugar-processing machinery to the value of £1½ million is to be supplied by Booker Brothers, McConnell and Company Limited, in association with Vickers-Armstrongs (Engineers) Limited, and negotiations with the Russians may extend this to orders for the supply of three complete sugar-beet factories. This would be worth about £11 million. Mr. R. E. G. Windsor, managing director of R. H. Windsor Limited, reported recently that the Russian Government had requested his company to design a complete factory. The factory would be for manufacturing high and low pressure polythene piping and rigid pvc.

Orders of this kind are usually for overseas countries which can hardly be called underdeveloped, yet they have some way to go yet in industrialisation. Mr. Windsor described Communist China as " a vast plastics market of the future." One can see his point. An unusual order, this time from Japan, was obtained recently by Humphreys and Glasgow Limited, of London. They will be responsible for the installation of two units of carburetted water gas plant. The plants will be manufactured and erected entirely in Japan, so the contract is worth only £25,000. In Romania, the growth of the chemical industry is providing work for many British firms. Lyddon and Company Limited, acting with Black Clawson Limited, signed a contract to supply a complete installation to produce cellulose and paper from straw and reeds. Romania is also likely to order from British firms complete plants for producing synthetic fibres, ethylene, and titanium dioxide, two complete breweries, and a plant for extracting oil from sunflower seed. Large-scale oil plants recently ordered from this country have included the platforming unit for a Mexican refinery, to be supplied by Fluor Engineering and Construction Company Limited through British Oil Equipment Credits Limited. This is valued at £3½ million. And Shell are to build New Zealand's first oil refinery at an estimated cost of about £17 million.

It is some years since Britain could claim to be the workshop of the world. These orders for process plants suggest that we can now claim to be the tool-room of the world. A " packaged deal " for a whole capital plant gives work to thousands of firms—all as a result of one main contract. It requires the kind of production engineering at which we excel—batch rather than mass production. And it requires that high order of integrated design which only a really advanced industrial nation can undertake. We may be a little uneasy lest the Russians and the Chinese and the Japanese are simply taking a short-cut to building all these things themselves. But like the schoolmaster with a brilliant pupil, we must keep one lesson ahead all the time. And when the " pupil " can do without us, there will be others for as far ahead as we can see.

The Institution of Chemical Engineers have evidently recognised the significance of these developments. They have revised their " scheme for a degree course in chemical engineering." In their new pamphlet which gives the syllabus for a three-year course, they stress an important point in education for the profession. They say that " the student must be taught from the beginning that money and economics as well as scientific principles are a part of plant design." If that is the philosophy behind chemical engineering, the fourth primary technology is destined to be one of the finest educational roads open to the future engineer.

We regret to state that because of the current dispute in the printing industry, which is affecting British periodical publishers, future issues of Engineering may be reduced in size or publication may be suspended temporarily.

Cover Picture.—*The flexible electric cable—flex—used domestically has a core of tinned copper. The picture shows the fine wires being bunched to form the conductor.*

(*Nurnberg photograph for* ENGINEERING)

Plain Words

Journalism is news today. Newspapers gossip about other newspapers; journals report on journalism; the Press figures in the press. Now that it is problematical whether we shall appear next week at all, I feel the urge to say a few words about the peculiar pitfalls of technical journalism.

I continue to be impressed by print; I'm always surprised to discover how some crummy stuff I've written goes all dignified when processed by the printers. It means you have to be specially careful. Take *The Times* report about the Foreign Secretary.

It just shows how dangerous indiscretions can be in the newspaper business. In technical affairs, accuracy may be almost as important. I remember how we nearly created havoc during the controversy about the Swedish church when we reported that a Stockholm rector was to be installed in Oslo. The word should have been "reactor." Then there are the laws of libel. Last week when I was trying to say what a low opinion we had of monkeys because they resemble us so closely, somebody, fearing repercussions, unconsciously illustrated my point by replacing the name of the prominent public figure, whose qualities I had compared with those of the now deceased Able, by some innocuous, but inappropriate sobriquet.

We are also required to see everything through a technical eye. I recall a remark by an erstwhile colleague of mine, now happily returned to teaching, concerning a former editor, now in well deserved retirement. We were looking down into the street as some fire engines ululated past, and I heard him mutter: "Thank goodness the old man isn't here, we'd be doing a special article on the technical features of fire-fighting next. But the old man had the right idea. A couple of weeks ago, a contributor wrote us a note about a recent fishing conference, and there wasn't a trace of engineering in it. Too few would-be journalists bother to examine or even read the journals which they hope will print their copy.

Then you struggle over titles. Naturally you've got to be fairly matter of fact in a technical magazine: no use trying to put over a universal grinding machine with some flower of the metaphorical imagination about mothers-in-law. But make a title too matter of fact and the very reader who complains most of superficial cleverness overlooks the article. It isn't easy to distinguish the clever from the apt, and maybe that's why clever, to the not so clever, becomes a term of disapproval.

Well I've got that off my chest. Maybe you think I'm looking forward to a period of enforced rest due to the printing dispute; but don't worry, the editor will have lots of ideas up his sleeve to keep us busy.

CAPRICORN

Weekly Survey

What They'll Think of Next

In 1958 there was increased interest in the field of patents for mechanical engineering, in automatic transmission devices for heavy commercial vehicles, in railway signalling systems and hay making machinery. Such was the trend for last year according to the comptroller-general of patents, designs, and trade marks in his 76th report.

In electrical engineering, the development in printed circuits continued with a marked interest in improving the qualities and stability of circuit components, especially those of miniature size. Transistors were finding increased uses in computers and there was activity in radar equipment for aircraft using the Doppler effect to determine movement relative to the ground. The application of analogue computers to control machine tools increased and there was considerable activity in the use of photoelectric cells for counting and sizing particles and for controlling exposure in photographic printing. There was a marked increase in specifications relating to nuclear reactors, particularly in the construction and loading of fuel elements. There was increasing interest in the use of radioactive substances to measure the physical properties of materials.

In chemical inventions there was less departure than in recent years from existing lines of progress. There were a number of specifications on the low-pressure polymerisation of olefines, in the preparation of new optical brightening agents, glutamic acid and new epoxy compounds used as stabilisers or plasticisers for vinyl resins.

Now We Are Seven

Progress with the Little Free Trade Area has so far been surprisingly rapid. It has been made easier by the initiative taken by Sweden as opposed to Britain and by the fact that most of the proposed members of the group are instinctively liberally minded on trade matters. The fact that the European Economic Community (the European Common Market) is now a reality has also acted as a spur.

The countries proposed for membership are Norway, Sweden, Denmark, the United Kingdom, Austria, Switzerland, and Portugal. Of these, the most difficult problems are those of Denmark which is anxious to keep both the United Kingdom market and the West German market for its agricultural produce. It, therefore, has the greatest immediate interest in establishing some sort of bridgehead for itself in the European Economic Community. To this end it has suggested a special arrangement between the proposed Little Free Trade Area and Benelux. This could not be more than a not very impressive thin end of the wedge for the Danes. If no agreement is quickly reached between the Little Free Trade Area, assuming it is established, and Benelux, the only hope will be that Germany will bring pressure to bear on France to accept an arrangement between the European Economic Community and the Little Free Trade Area because Germany is at a serious disadvantage in the Scandinavian market. The Federation of British Industries has now begun a formal investigation into the LFTA scheme.

Economic Fallout

The *World Economic Survey, 1958*, which is published by the United Nations is concerned about the quantity of idle labour and equipment still to be found throughout the world despite the economic recovery. The report finds that fear of inflation is holding back progress.

This attitude of mind is apparent in the United States and there is good cause for it. At a time when the recession was gathering impetus in that country there were also indications of inflation, notably in consumer spending habits and the upward trend of retail prices. There is a marked difference of opinion about how quickly the major industrial countries, and for that matter the world as a whole, should emerge from recession into boom.

Controversy of this sort is breaking out nearer home. The latest issue (No. 3, May, 1959) of the *National Institute Economic Review* offers a more optimistic view of the immediate economic future in this country than it has done in the past. Taking into account the effect of the Budget, the review estimates that industrial production will be 4 or 5 per cent higher by the end of this year than at the end of 1958. The London and Cambridge Economic Service, however, thinks that the Budget did not go far enough in that the consumer boom, which has lasted longer than anybody had expected, will peter out before the capital goods industries can recover.

There is little doubt that exports will play a critical part by the end of this year. This country's buoyant exports have been heavily dependent recently on shipments of cars and aircraft, notably to the United States market. Aircraft exports prospects are beginning to fall off and the boom in imported small cars in America may not last for ever. The export position may hold the key to the later stages of recovery in this country in the winter of this year and the spring of 1960.

Express Radio Link

The latest of the already not inconsiderable achievements of French Railways is the introduction of a new interesting express service which averages 72 m.p.h. It covers the 156 miles between Paris and Lille in 2 hours 10 minutes. The train is one of the newest to be introduced, all stainless steel, and hauled by electric locomotives working on 25,000 volt a.c. There will be four services a day, one train leaving each town in the early morning (7·30 from Paris and 7·07 from Lille) to enable the businessman to arrive in good time for a day's work. He can catch a train back as late as 7·09 p.m. from Paris and 6·00 p.m. from Lille.

A most interesting development is the availability of telephones on the train. There is a radio link between the moving train and eleven 130 ft high aerial pylons set up at intervals alongside the track. Passengers can be connected with any telephone subscribers in France and other European countries on payment of a small surtax (about 3*s* above the normal charge for the class). They can also be called by subscribers on Paris-Oberkampf 97–69. This means that a great deal of work could be done from 8 o'clock onwards (when most French offices open) by those who feel energetic at that hour to arrange appointments or check upon their arrangements for the day. This is getting very close to the ideal businessman's inter-city transport and French Railways are to be congratulated on showing so practical an appreciation of his needs.

Bloc Oil Distribution

A scheme for a pipeline to carry crude oil has been worked out by Soviet engineers to serve Poland, Czechoslovakia, Hungary and East Germany from the Volga region. The pipeline

would be 2,500 miles long and would run from the Volga into White Russia where it would divide, the northern line supplying Poland and East Germany, while the southern one ran into Czechoslovakia and Hungary.

The Russians estimate that the pipeline will cover the entire crude oil needs of the four countries. Its appeal to the Russians is obvious enough. There have been plenty of indications that the Russians have an oil surplus and a pipeline to their satellite countries would be a good and economic way of selling what they do not want themselves. It would also make these countries completely dependent upon Russian oil if the scheme goes through.

From the point of view of the satellites the scheme would probably be a mixed blessing. If the price of the oil were based on a genuine costing, the plan might have important economic attractions to them. The price might, however, have as many strategic implications for all parties as the pipeline itself. Apart from the price, future oil refineries would be bound to be sited near the pipeline. Altogether, it is an interesting and, from the Russian point of view, satisfactory package deal in terms of economics and politics.

Coal Clairvoyance

The National Coal Board's report and accounts for 1958, which have been recently published, show the agonies through which the coal industry is passing in an effort to pursue an intelligent programme of long-term investment and an enlightened employment policy against a background of over-optimistic forecasting in the past few years. Last year the industry made a net loss of £3·5 million, but this figure includes a large credit for taxation provisions no longer required and before this provision was added back the loss for the year was £13·4 million. At the end of last year the National Coal Board held stocks of nearly 20 million tons and it is likely that a further 3 million tons will be added during 1959. Plans have, therefore, been made for 1959 to cut back production. They include a reduction in opencast output, speedier closing of uneconomic pits and a policy of greater concentration of production by eliminating high cost faces. Probably only optimists will expect these plans to go into action quickly enough and coal stocks by the end of this year may well be between 25 million and 30 million tons.

All the fuel and power industries have been over-optimistic in the past few years about the trend of demand for energy. There has been a good deal of facile extrapolation of past trends in the light of prospective increases in industrial production. It is vital for the coal industry, which rightly is continuing a policy of bold long-term capital investment, to have closely accurate forecasts of demand. It is equally important to assess which markets can take higher prices or more coal—or both.

Sir James Bowman, chairman of the National Coal Board, made it quite clear in his address to the National Association of Colliery Managers that the coal industry is now in the throes of long-term acute competition on a major scale from alternative fuels. In the last two years gas made from oil, together with the tail gases bought from refineries, increased by over 100 per cent. The capacity of oil gasification and refinery gas reforming plant is estimated at nearly 190 million cu. ft a day which is equal to the gas produced by 3 million tons of coal a year. Much of this successful competition by oil is due to the price factor.

Protecting Design

When a Private Member's Bill was withdrawn last year on the protection of industrial designs, a certain amount of consultation within industrial and professional organisations showed that there is considerable dissatisfaction with the law on this subject. A departmental committee has been set up by the President of the Board of Trade to review the regulations without at the same time reviewing the law of patents or copyright.

The chairman of the committee will be Mr. Kenneth Johnson, Q.C. The committee includes representatives from the toy industry, retail trading and jewellery. Other members are patent agents, the Controller-General of Patents, Designs and Trade Marks, and other authorities on design, patents and copyright.

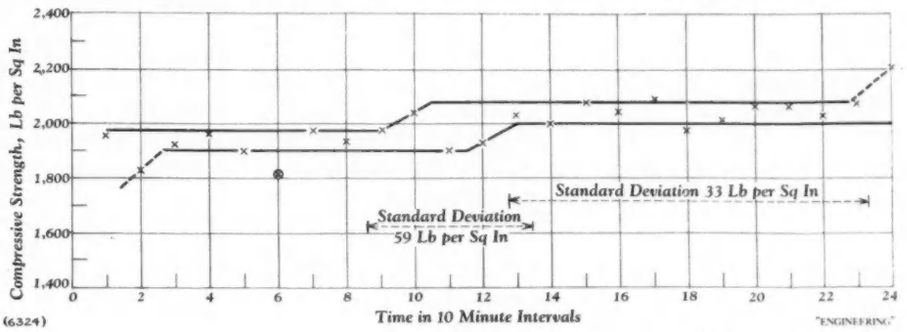
There is a tendency to consider the problems of design in terms of consumer goods, particularly those which over the years have been pirated by foreign manufacturers. In this respect textiles, toys and jewellery have been particularly vulnerable. Other industries also have their design problems, including engineering. In this case the problem of copying designs is particularly difficult to control because design and function are so closely related. In certain consumer goods the appeal is to the eye and appearance is therefore very closely related to marketability. This is much less apparent with capital equipment, but even here the engineering industry is learning that function and appearance are closely connected and can help each other in marketing equipment. On the light engineering side the problems of design are very much more closely related to those in the consumer goods industries. It is to be hoped that the committee review the protection of design in the widest will possible context.

Water Engineer Identified

Giving his presidential address to the Institute of Water Engineers recently, Mr. Donald Whiteley drew attention to the scope which still exists for establishing the identity of the water engineer within the engineering profession as a whole. This identity is bound to be further established by the development of organised research within the water engineer's profession. The Water Research Association began to take over the main programmes of various research groups in January, 1956. Mr. Whiteley said that it was probable that recognition would be forthcoming by the Department of Scientific and Industrial Research, and a grant from the Government to help carry out a number of research programmes over the next five years, might therefore be forthcoming.

He called for more publicity for the profession as a whole and emphasised particularly the vital factor of recruitment and training future water engineers. He considered that new water undertakings should employ qualified water engineers, and this meant corporate members of the institution. Only in this way could the best results be achieved in modern plant and methods of operation. In turn this would lead to bigger opportunities for water engineers and would increase the attractiveness of the profession. He also made a plea for the study of management. A summer school has been organised by the northern section to study the problem of water works administration in all its aspects.

ACCELERATED CURING TESTS ON CONCRETE



SIR, Last year you published some interesting correspondence on two methods of accelerated concrete testing; the oven method developed by Professor J. W. H. King, and the boiling method by Mr. T. N. W. Akroyd and Mr. R. G. Smith-Gander.

In both these nominally six or seven-hour tests, it is necessary to adopt modified curing cycles for concrete cast within six or seven hours of the end of the working day. As these may take up to 24 hours, I was interested to see the effect of curing in water for 24 hours at a constant but lower temperature. I found that a temperature of 35° C gave approximately the same cube strengths as in Professor King's oven method, and this at once provided a basis of comparison between the two methods without the need to establish new curves for forecasting the 7 and 28 day strengths.

Using a variety of cements, sands, coarse aggregates and mix proportions, I have found little to choose between the accuracy of these methods, and all three leave something to be desired when forecasting the strengths of concrete made with unknown materials. Nevertheless, the 35° C method of curing is so convenient, requiring no supervision or expensive equipment, that I find it worthwhile keeping a tank of water at that temperature in the laboratory to obtain an additional and early check on concrete strengths.

While developing this method, I have been interested to find that, for a given concrete, there is a period of several hours during the first 18 after casting when the rate of increase in strength is about the same whatever the curing temperature between room and 100° C.

A further interesting phenomenon is that, at both normal and higher curing temperatures, for at least part of the 24-hour cycle, periods of strength development alternate with periods of constant strength. This is illustrated by the accompanying graph, which shows the strengths of individual cubes which were tested at ten-minute intervals after being in the 35° C curing tank for between 18 and 22 hours. It will be seen that the scatter in the region of increasing strength is about twice that in the region of constant strength, which might be explained either by assuming that the patterns of strength development of individual cubes are "out of phase" with each other along the time ordinate, or simply that the period of strength increase varies for different cubes.

Whatever the explanation of the stepping effect, it is clear that the degree of scatter obtained when testing batches of cubes at early ages is partly dependent upon the time of testing. The graph shown is typical of a number I have obtained, and the difference in scatter between the periods of constant and increasing strength can be even more marked.

It seems possible that this phenomenon may also at least partly explain the scatter obtained when testing cubes at 7 and 28 days.

This letter is submitted by courtesy of my employers, John Laing and Son Limited, in whose laboratory the work has been carried out.

Yours faithfully, M. S. THOMPSON

Barnet, Herts.
28 May, 1959.

OIL FREE BLOWER
Silent Lightweight Units

OIL free blowers with capacities up to 1,000 cu. ft per hr at 10 lb per sq. in are now available.

These units are made in six sizes for either 5 or 10 lb per sq. in pressures and can be fitted with exhaust silencers if required. For single phase supplies split phase motors can be used owing to the small starting torque. The model illustrated has a capacity of 180 cu. ft per hour at 5 lb per sq. in delivery pressure. They are said to be particularly suited for the plating, milk and glass blowing industries.

The rotors are fitted with non-metallic sliding vanes and a face type seal prevents leakage past the shaft. All parts are interchangeable. Standard blowers are supplied complete with intake combined filter and silencer and relief valve. The larger models can be used as vacuum pumps and they are then fitted with intake pipeline filters and vacuum relief valves. It is claimed that when they are fitted with exhaust silencers the blowers are almost silent in operation.

Installation is said to be easy, requiring only connecting wiring and pipework. Maintenance is also said to be negligible. The units can be moved from place to place and need not be bolted down as the vibrations are very small. *William Allday and Company Limited, Stourport-on-Severn, Worcestershire.*

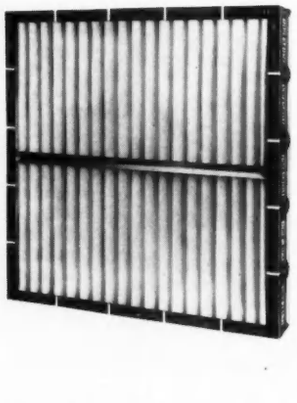
AIR FILTER
Designed for heavily Contaminated Conditions

THE Super-Vee air filter panel has been designed for use in areas where the contamination of the atmosphere reaches smog conditions.

The panels have a fibrous medium impregnated with an adhesive which is claimed to give them a longer life and to collect sooty or tarry deposits without the danger of fibre migration. They are expendable.

The panels have been tested in accordance with BS2831. Using Aloxite 50 dust (mean particle size 5 microns) a panel measuring 20 in by 20 in showed a dust holding capacity of 980g at 0·5 in water gauge. This is equivalent to a load of 400g per sq. ft of effective face area. Initially an efficiency of 96 per cent was achieved and was held for much of the life. At the rated air volume of 100 cu. ft per minute for a panel measuring 20 in by 20 in by 2 in deep an initial restriction of only 0·08 in w.g. was experienced.

The panels are made in 27 sizes ranging from 10 in by 10 in and 1 in



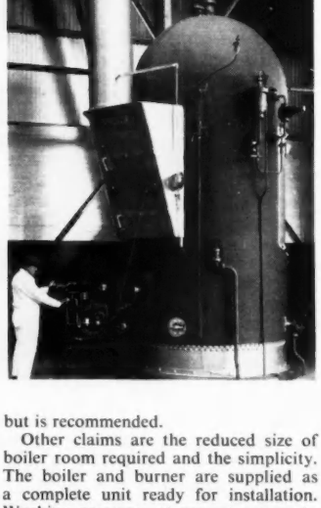
thick, to 20 in by 25 in and 2 in thick. The corresponding range of capacities is from 250 to 1,250 cu. ft per minute. The standard rated air velocity is 400 ft per minute. Panels should be replaced when the pressure drop reaches 0·5 to 0·6 in w.g. *Vokes Limited, Guildford, Surrey.*

VERTICAL BOILERS
Operating Efficiency above 80 per cent

INITIALLY the new range of Cochran vertical boilers will cover steam outputs from 1,750 to 8,300 lb per hour from and at 212° F. The heat transfer efficiency is guaranteed at above 80 per cent.

This series II range is for oil firing and incorporates a multipass system. They are based on the existing types. The combustion chamber has been enlarged and the smoke tube bank has been divided by baffle plates to give three passes. Comparatively small bore tubes are used, the bore increasing with the size of boiler.

Firing is by a Brockhouse burner and one of the special features claimed is that the boiler can be converted for solid fuel in less than a day, the only changes required being the removal of the burner and of the two baffle plates, and the introduction of a grate and an ashpit door. The boiler will then work under natural draught whereas the oil fired version has a forced draught of 1·5 in water gauge. A stack is not necessary



but is recommended.

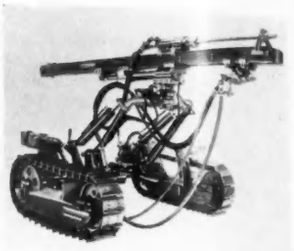
Other claims are the reduced size of boiler room required and the simplicity. The boiler and burner are supplied as a complete unit ready for installation. Working pressures at present are up to 150 lb per sq. in. *Cochran and Company, Annan, Limited, Annan, Dumfriesshire.*

DRILLING RIG
Self Contained Unit for Large Deep Holes

A SELF-PROPELLED track-mounted drilling rig, mounting a 4 in or 4½ in drifter, has been introduced for large diameter deep hole drilling.

In this unit, two 6 b.h.p. Power Vane reversible motors provide the motive power for propelling the rig round the site at a speed of 2½ m.p.h., while towing a 365-RO-2 Power Vane compressor which supplies the compressed air.

The rig carries a drilling mast which is retracted to the horizontal position for travelling or positioned at any angle for drilling by means of hydraulic cylinders. The unit can also be supplied with a further pair of cylinders for inclining or swinging the drill carriage. Other features include heavy duty multiple disc brakes which eliminate movement during drilling, a throw-out clutch for towing, totally enclosed drive, and a hydraulic drill positioner control panel. The crawler control is of the spring-loaded "deadman" type and gives forward, reverse, turning and pivoting movements.



The unit has a low centre of gravity, and this, combined with independent operation of the 10 in wide tracks, enables stability of the carriage to be maintained in rough conditions. The drill used is the CP400 or CP450, these being 4 in and 4½ in piston units, respectively.

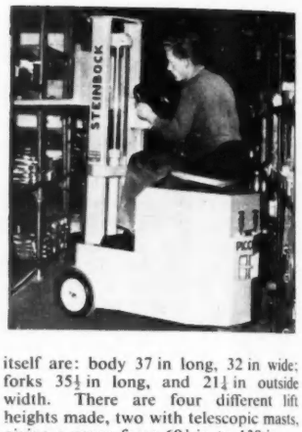
Specifications of the Tracdrill include an overall length of 86½ in, a width of 84 in and a maximum height, with mast lowered, of 44 in. It has a ground clearance of 14 in. The total weight, complete with drill carriage and drill, is 5,265 lb. *Consolidated Pneumatic Tool Company Limited, 232 Dawes Road, London, SW6.*

FORK TRUCK
For very Confined Spaces

THE Piccolift fork truck has all the advantages of the rider controlled type with a body length of only 37 in, allowing the truck to be used in narrow aisles.

The trucks are electrically driven from a 24 V battery, there being separate motors for each of the front wheels. Steering is by the single rear wheel. The lift pump is supplied by a third motor. Two versions are available with the same lifting capacity (1,120 lb at 24 in centres or 1,300 lb at 20 in centres), but one has 500 watt driving motors giving forward speeds of 4 and 4½ m.p.h. and a draw bar pull (short time) of 185 lb; and the second has 1,000 watt motors increasing the forward speeds to 5 and 5¾ m.p.h. and the draw bar pull to 530 lb, roughly equivalent to a 10 ton load.

When carrying a pallet measuring up to 30 in by 48 in the truck can turn in aisles 87 in wide. With the same size pallet it can stack at right angles in aisles 83 in wide, or at 45° in one 44 in wide. The dimensions of the truck



itself are: body 37 in long, 32 in wide; forks 35½ in long, and 21¼ in outside width. There are four different lift heights made, two with telescopic masts, giving a range from 60¼ in to 138 in.

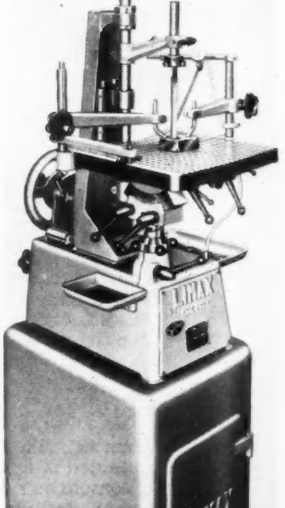
A pedal operates the change speed control and a hand lever the forward and reverse. The steering wheel has a full 180° lock and the inner driving wheel automatically free wheels on close turns. Foot and hand brakes are fitted. *G. Hunter (London) Limited, 80 Fenchurch Street, London, EC4.*

FILING MACHINE
For Medium size Work

THE Limax filing machine is for the small or medium sized factory requiring a general purpose tool.

The file is driven by a ⅓ h.p. motor, running at 900 r.p.m., through belts and pulleys giving speeds of 95, 135, 175, 230 or 335 strokes per minute. The length of stroke is adjustable from zero to 80 mm. A workpiece up to 70 mm in thickness can be accommodated, and the table has a height adjustment of 60 mm. The table can be tilted up to 15° forward or backward and up to 5° sideways. It has a diameter of 300 mm. A quadrant plate below the table shows the angle of tilt.

The machine can be supplied for floor or bench mounting. The motor and the controls are housed in the base and there are side trays for tools. The column and the arms are of rigid construction, the arms being adjustable on the column. At the top is a built-in air pump. A bandsaw and fixings canbe supplied. *South Coast Engineering Company, Palnut Works, Arthur Street, Hove, 3.*



TRACTOR SHOVEL
Three Tine Ripper Fitted

THE FL4 is a crawler tractor fitted with a shovel and a three tined ripper as standard equipment.

Power is supplied by a Fiat four stroke diesel engine producing 40 h.p. at 2,300 r.p.m. There is a built-in oil filtering system working through a centrifugal cleaner and a replaceable filter cartridge.

The engine drives through a gearbox which gives four speeds forward and four reverse. Top speed forward is 5·1 m.p.h. and 5·5 m.p.h. is top speed in reverse.

The transmission system includes a quick reverse mechanism which gives a change of direction without the need for changing through the gears. Clutch and brake steering is used emphasising that the machine has been built as an integral crawler tractor unit.

The machine is built with a ¾ cu. yard tip back bucket and an integrally constructed three tine hydraulic ripper. The bucket is 4 ft 7 in wide and has a maximum discharge height of 7 ft 4 in at a 45° angle; at this height a dumping reach of 3 ft 1 in is obtained. The maximum dumping angle of the bucket is 68°. The ripper has three tines that can be set to any one of five different positions according to the type of work involved. The maximum working depth is 10 in. These tines can be reversed when not required for use.

The FL4 tractor shovel weighs 8,800 lb and is 14 ft 1 in long overall; the width is 4 ft 8½ in. Standard equipment includes starting and lighting systems for 24 V supplies. Shown at the Building Plant Exhibition by *Mackay Industrial Equipment Limited, Faggs Road, Feltham, Middlesex.*

BENDING MACHINE
For Black Bars up to 1½ in diameter

AN addition to the Staffa range of pipe benders is a machine for bending steel bars used for reinforcing concrete.

Small, compact, easily transportable and semi-automatic, the machine has been designed for the cold bending of black mild steel bars up to 1½ in diameter. A feature is that it can be easily arranged for multiple bending of smaller rods.

The frame is constructed of steel throughout and all gearing is machine cut. Ball races are used in all bearing housings, with the exception of the main spindle, which has heavy bronze bushes suitable for side thrust. Working surfaces are machined and provision is made for lubrication. A three-way control handle is fitted for the forward, neutral and reverse positions, and the rotating roller attached to the plate is controlled for angle of bend by means of a pin which can be placed in any of the holes provided. In order to obtain the maximum bending speed, three speed pulleys are provided in an accessible position, and guarded, while a magnetic brake is fitted to prevent overrun.

The unit is powered by a 3 h.p. drip proof motor on an adjustable tensioning table and provided with an isolator switch suitable for an electrical supply of 440 V, 3 ph. 50 c/s.

Interchangeable steel formers equal to 4 × D are provided to bend concrete reinforcing bars from ⅜ in to 1½ in diameter to standard radii. *Chamberlain Industries Limited, Staffa Works, Staffa Road, Leyton, London, E10.*

REDUCING VALVES
For all Factory Services

FOR all factory services, steam, gas or air, a range of pressure reducing valves has been introduced.

Known as the type 470 the chief claims for them are that there is only slight variation in downstream pressure due to flow demand up to the maximum rated capacity, or due to changes in upstream pressure. A tight closure can be obtained, and there is said to be a complete absence of chatter. The spherical valve is self cleaning and the seat is renewable.

The valves are suitable for upstream pressures of 250 lb per sq. in for steam, or 300 lb per sq. in for air or water, and can operate at temperatures up to 450° F. The maximum downstream pressure for the ½ in and ¾ in sizes is 150 lb per sq. in, and 125 lb per sq. in for the remaining sizes up to 2 in. Pressure alterations are made by a screw adjustment.

The bodies are made from bronze castings but the wearing parts are in stainless steel. An integral strainer is fitted. *Samuel Birkett Limited, Queen Street Works, Heckmondwike, Yorkshire.*

TRUCK MOUNTED CRANE
25 Tons Capacity

A RECENT addition to the Neal range of cranes is the NL250 track mounted model, shown here on a Thornycroft chassis.

The jacked capacity is 25 tons (25,400 kg) at 10 ft (3·05 m) radius and 9¼ tons up to 10½ tons at 10 ft radius fully mobile, dependent upon the chassis, of which various types are available. The mobility of this crane makes it particularly suitable for use in cases where it is necessary to travel to and from various sites with minimum delay, to avoid crane waiting time between lifts.

Full circle slewing in either direction on patent cross-roll bearing gives even distribution of load and extremely smooth action, and all loads can be handled throughout the 360° slewing circle in either direction.

The crane is direct diesel drive throughout, and is powered by a Ford 4-cylinder industrial diesel engine developing 50 b.h.p. driving through a torque converter. All motions are power hydraulically operated, fully independent, and can be operated separately or in any combination. The hoisting unit incorporates the Neal safety hoist device.

Jibs are of lattice construction, standard lengths from 30 ft to 120 ft maximum, and fitted with load indicators giving maximum permitted loads at various radii. A double drum can also be fitted of 4 tons capacity, to enable a dragline or double rope grab to be used. Shown at the Building Plant Exhibition by *R. H. Neal and Company Limited, Plant House, Ealing, London, W5.*

TRANSISTOR TESTER
Quick Routine Checks of Gain and Leakage

THE type R2285 is a low priced set for run-of-the-mill checks on transistors of the type required in the normal production shop where large numbers of transistors have to be tested quickly.

The set provides a quick, direct indication of current gain and collector leakage current of PNP transistors when operating under common emitter conditions.

Current gain (Beta or α′), within a range 10 to 150, can be read directly on a calibrated dial by adjusting until an audible note just ceases. This measurement can be carried out at a collector current of 0·5 to 4 mA, the set collector current being read on a meter on the instrument.

Leakage current is measured on the meter, at a fixed collector voltage of 9 volts. A push-button switch alters the range of the meter to 500 μA full scale deflection for this test. Accuracy of measurement is within 5 per cent or plus or minus 5 which ever is the greater.

The test set is a battery-operated transistorised unit housed in a robust die-cast box.

The transistor that is under test is connected by means of quick-release terminals, and both measurements can be carried out by unskilled personnel in a few seconds. Full operating instructions are printed on the back cover of the instrument. *Siemens Edison Swan Limited, 155 Charing Cross Road, London, WC2.*

SPARK EROSION
Very High Rates for Removal

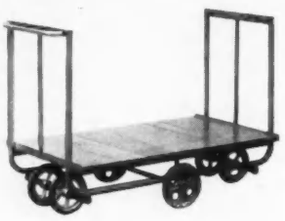
THE RIG equipment is essentially for use as a roughing medium as its rate of stock removal is in the region of 10 to 20 times faster than the standard Mark III Sparcatron.

The equipment consists basically of the normal Sparcatron Mark III machine head working in conjunction with a rotary impulse generator (hence the initials RIG) and a control cabinet, the latter being provided with tappings for power supplies in the ranges of 200 to 250 volts (10 volt steps), 340 to 440 volts (20 volt steps) and (for the Canadian market) 500 volts. It is suitable for 50 or 60 cycles.

A pulse frequency of 400 per second, at a peak output of 250A removes stock at the rate of approximately 4 cu. in per hour using brass, copper or Mazak electrodes. The rate of wear for copper or brass electrodes is in the region of 0·3 in for 1 cu. in of stock removal. *Burton Griffiths and Company Limited, Mackadown Lane, Kitts Green, Birmingham 33.*

PLATFORM TRUCKS

For General Factory Use



THE Flagship range of tubular steel platform trucks consists of nine models.

In general they are made of tubular steel frameworks with timber platforms. There are special handles at the top to give added protection for the fingers of the user.

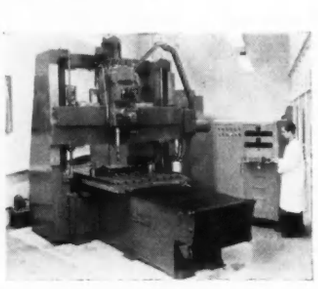
The timber platform is normally of nominal 1 in thick seasoned wood attached to the angle frame. There are three sizes of platform. These measure 36 in by 24 in; 42 in by 27 in; and 48 in by 30 in. All platforms are 11½ in above the ground and the overall height of all models in the range is 36 in. The load carrying capacities of the three sizes of platform are 5 cwt, 7½ cwt, and 10 cwt respectively.

In addition to the model shown in the illustration there is a double-decker version which has a detachable shelf fixed nearly at the top and made of nominal ¾ in softwood. The supporting angle runners for this shelf are placed so that they offer no obstruction when the base platform only is in use.

Standard fittings on the lighter trucks include aluminium diecast wheels with rubber tyres which are said to have exceptional resilience. The three heavy-duty models are fitted with six running wheels of which the centre two are 9¼ in diameter and have cast iron centres with vulcanised rubber tyres. The two wheels at each end are 7 in diameter having aluminium diecast centres. As an extra, the centre wheels can be fitted with roller bearings. Slatted uprights can be provided on any model. *Angel Truck Company Limited, Meteor Works, 215-219 Albion Road, Stoke Newington, London, N16.*

DRILLING MACHINE

Designed for Electronic Control



THE Wadkin tape controlled drilling machine has been specifically designed to enable full advantage to be taken of the high degree of accuracy provided by modern electronic positional control systems.

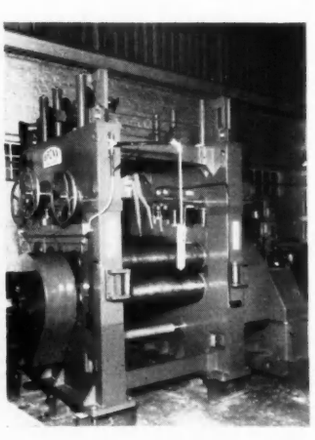
The machine has been designed and built with a table capacity of 60 in by 40 in and a maximum daylight under the bridge of 40 in. The drilling head is an all geared unit having 12 spindle speeds from 60 to 1,500 r.p.m., with six rates of feed from 0·004 in to 0·030 in per rev. Both the table and the drilling head are automatically locked by means of a high pressure hydraulic system during each drilling cycle. The drilling capacity in mild steel is 2 in diameter from the solid, but holes up to 3 in diameter can be drilled at reduced feed rate. The machine is arranged to operate manually in the normal way for initiating the feed on prototype work or the cycle can be initiated from the tape.

Special features that have been included in the design are the anti-friction slides and the precision recirculating ball nut and screw devices that ensure consistent accuracy in positioning. The machine operates from EMI controls using punched tape or dial settings and does not need an external computer. The tape is suitable for batch production and the dials for one-off operations. The machine also allows for hand setting and control. It is not necessary to drill pilot holes.

The beam has a rise and fall rate of 15 in per minute and the modified Archdale head is driven by a 5 h.p. motor. *EMI Electronics Limited, Industria, Applications Division, Hayes, Middlesex.*

PLATE LEVELLER

Six Roll Heavy Duty Machine



THE Bronx six roll leveller has been designed for mild steel plate up to 5 ft by 2 in, or 1 ft by 4 in, and equivalent high tensile plate sizes.

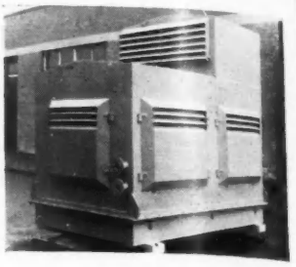
The machine has a pair of pinch rolls and four levelling rolls. The body length of the rolls is 5 ft 4 in. The pinch rolls are 17 in in diameter and the bottom rolls are also 17 in diameter. The top centre roll is 19 in and the outgoing top roll is 15 in in diameter.

The upper pinch roll and the two upper levelling rolls are each separately adjustable by means of three 10 h.p. motors. Indicator dials show the position of each roll. Large diameter double hand wheels are provided for all top tolls by means of which the operator can, if required, tilt these rolls to assist in taking out edge camber. The hand wheels can also be used to give a fine adjustment to the position of the top rolls. Shear pins mounted in hardened and ground bushes are fitted to the pinch roll chocks.

The drive is taken from a reversing 80 h.p. motor, fitted with a magnetic brake, through a double reduction totally enclosed gearbox and double helical gearing to the three lower rolls to give a levelling speed of approximately 15 ft per minute. The phosphor bronze bearings are automatically lubricated. *The Bronx Engineering Company Limited, Lye, nr. Stourbridge.*

AIR CONDITIONING

Unit for Deck Mounting on Ships



THE Norris deck mounting air conditioning unit is designed for ships that already have a mechanical heating and ventilating system, but require air conditioning to be added.

One feature is that the refrigeration compressor and the air cooler are mounted on an integral base supported on vibro insulators to reduce to a minimum the transfer of mechanical noise through to the deck. This arrangement also minimises the chance of fracture on the gas and liquid lines.

The unit is connected to the heating and ventilating system by means of heavy gauge trunking while various sizes of compressors can be fitted in each unit to extract up to a maximum of 250,000 Btu per hour. The units are designed to be operated on 25 per cent fresh air and 75 per cent recirculation. The actual internal temperatures obtained are directly related to heat ingains, sun effect, etc. They can be provided with or without air filters.

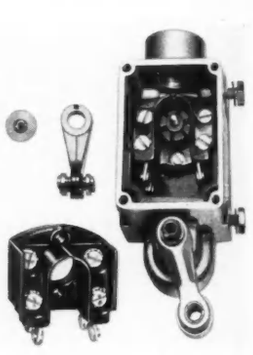
The refrigeration machinery which is housed in the unit is complete with a water cooled condenser of the shell and tube type with connections for sea water mains or a separate pump as desired.

The running of the machinery is entirely automatic being controlled by a thermostat fitted in the return air trunk while in addition high and low pressure cut-outs are fitted as safety devices.

Overall dimensions are approximately 8 ft 6 in by 5 ft 6 in by 6 ft 3 in high. The units can be supplied separately or as part of a complete heating and ventilating system. *Norris Warming Company Limited, Cross House, Westgate Road, Newcastle upon Tyne 1.*

LIMIT SWITCH

Improved both Electrically and Mechanically



MODIFICATIONS incorporated in the Mark II Snap-Lock Switch are to ensure complete interchangeability of assemblies in all types of Mark II models, and improve resistance to dirty, wet conditions.

The electrical unit now comprises only two assemblies, the contact arm and the contact block. To remove the arm it is only necessary to remove the lock-nut which holds it to the spindle. The contact block is now a one-piece structure with its contacts incorporated during the moulding process. This moulded block has no side securing screws passing through the outer case of the switch, which gives better electrical resistance to earth and further protection against the ingress of dust, water or oil. By removing the contact arm, as previously described, two securing screws are revealed, which, when removed, enable the block to be lifted out and a new one fitted in its place. The one-piece block also reduces the possibility of electrical failure.

Minor modifications to the mechanical components—for instance, improved seatings for the return springs and the simplification of change-over or replacement for the spring location by the use of more efficient latch retaining clips—are factors towards the aim of a reliable limit switch.

These improvements are incorporated in all types of Snap-Lock switch including the flameproof version. *BSA Tools Limited, Mackadown Lane, Kitts Green, Birmingham 33.*

BOLT DRIVER

High Frequency Units up to 1½ in diameter

A LARGER model has been added to the Bosch EW/HR106 range of high frequency bolt drivers that will take sizes up to ⅞ in threads.

The driver can be supplied from the normal three phase mains through a frequency converter or it will work from a 2 kVA portable generator having an output of 110 V or 135 V at 200 c/s. Such a generator can be transported in a 30 cwt van.

The tools have an accurate torque setting and are claimed to give trouble-free operation. Since there are no armatures to burn out, maintenance costs are low and the running costs are said to be one fifth of a similar pneumatic tool. They are fitted with safety impact couplings to prevent them running away with the operator. By using spring loaded suspension the weight of the tool is relieved.

The tools have an output of 1,200 watts and weigh 38 lb. When running in ¾ in square headed bolts on railway sleepers each bolt takes approximately 2 seconds to fix. *Trend Industrial Equipment Limited, 77 and 95 Dudden Hill Lane, London, NW 10.*

ANGLO-RUSSIAN SCIENCE SWOPS

Many matters of commercial and scientific interest were brought before the House of Commons when Parliament reassembled on 2 June, after the short Whitsun recess. Among the questions put forward were several addressed to Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, relating to the progress and achievements of the Department of Scientific and Industrial Research.

Mr. Harold Gurden (Conservative) suggested that, in view of Russian advances in certain aspects of scientific research in iron and steel technology, steps should be taken to encourage the exchange of scientific information and experience on this subject between Britain and the Soviet Union.

He was informed by Mr. Nicholls that, in addition to the normal arrangements made for exchanges of technical literature, preliminary visits were exchanged towards the end of last year between the British Iron and Steel Research Association, which is the cooperative research organisation grant-aided by the DSIR, and a corresponding research organisation in Russia. Consequently, it was agreed by these two organisations that there should be exchange visits by small groups of specialists to study certain facets of metallurgical research.

The first British group, who were specialists in the continuous casting of steel, visited Russia in April and it was expected that the Russian group would visit this country in June, but, said Mr. Nicholls, he could not give the exact date.

CINE CAMERAS WORK FOR SCIENCE

Another subject raised by Mr. Gurden was the value of cinematography for scientific purposes. He asked if the work being done in this connection in Russia was being studied in this country.

Speaking on behalf of the Lord President of the Council, whose representative he is in the Commons, Mr. Harmar Nicholls, said that the Department of Scientific and Industrial Research had recognised the importance of the subject by holding a conference in London under the title of " The Cine Camera and Industrial Research " in April last year. It was attended by more than 300 representatives of research organisations. An appreciable amount of information on the extensive use in the Soviet Union of cine films for scientific purposes was obtained at the twelfth congress of the International Scientific Film Association held in Moscow in September last year.

The thirteenth congress would take place this year in Oxford and London. The Government had undertaken to finance this year's congress to the extent of £2,500, provided that industry found an equivalent amount.

DESIGNING HYDRAULIC MACHINERY

An inquiry was made by Lieut.-Colonel J. K. Cordeaux (Conservative) as to the extent of the facilities available within the Department of Scientific and Industrial Research to help in the design of hydraulic machinery which could be used efficiently in hydro-electric pump-storage schemes.

Mr. Harmar Nicholls replied that the Department's National Engineering Laboratory had installed special rigs for testing very accurately pump models, up to 300 h.p., over a wide range of working conditions, including those met with in pump-storage schemes. He thought that industry was making proper use of these important facilities. Indeed, nine firms had taken advantage of this rig, and everything pointed to the fact that the results they had obtained would encourage more bodies to do the same thing. He was asked by Mr. Arthur Woodburn (Labour) whether this was something new, or whether it was an improvement on what had been contemplated in connection with the hydro-electric pump-storage scheme at Loch Sloy? He asked if the House was to take it as certain that the very latest methods would be employed in connection with that scheme.

Mr. Nicholls said that he thought that the apparatus was an improvement on the past, but that, without wishing to commit himself too deeply, without notice, he did not think that there was anything specifically new about it. A lot of thought had been given to the provision of test equipment to avoid the waste of electricity in off-peak periods. The pumps referred to might be used as part of a particular process.

PRESTRESSED CONCRETE IN FIRES

A further research subject, the susceptibility of prestressed concrete to damage by fire, was raised by Mr. Robert Jenkins (Conservative). He asked what research had been carried out in that regard and whether the Government would ensure that the fire-resistant properties of this material were made more widely known.

Mr. Harmar Nicholls said that, in cooperation with the Building Research Station, the Joint Fire Research Organisation of the Department of Scientific and Industrial Research and the Fire Offices Committee had carried out research on the resistance to fire of prestressed-concrete beams and floors. As a result, the early fears about the ability of this new form of construction to withstand fire had been shown to be unfounded.

The results of this work were to be published in a Code of Practice by the British Standards Institution. Perhaps the best compliment that could be paid to its efficacy, however, was the fact that prestressed concrete had been chosen for a large new laboratory for the Fire Research Station, which had been designed for the carrying out of fire experiments.

ELECTROPLATING WASTES

Attention was drawn by Lieut.-Colonel Cordeaux to the need for continued investigations into the treatment of electroplating wastes, particularly those containing cyanides. He felt that the knowledge obtained should be brought to the notice of the firms concerned, so that they would not spend a lot of money unnecessarily on expensive plant, when something cheaper was just as good.

Full-scale chemical treatment plant, said Mr. Harmar Nicholls, had been installed in many factories and, in addition, experiments on a pilot scale had shown that certain types of cyanide waste could be treated by a biological process, which, in suitable cases, might be cheaper. That supposition had yet to be confirmed in a full-scale plant.

The results so far obtained had been very widely published and, after the experiments have been confirmed, even greater efforts would be made to see that people who could profit from the process would have all the details regarding it.

EUROPEAN AIRLINES MERGER

Mr. Frank Beswick (Labour-Cooperative) wanted the Minister of Transport and Civil Aviation to make a statement regarding the proposed European consortium of airways corporations and its probable impact on British operators.

Mr. Beswick asked if there was not a lesson to be learned from what was happening in Europe at the present time. Organisations there were cooperating, eliminating overlapping schedules, and getting together as airlines, while in this country the Minister was doing precisely the opposite. He was splitting up the traffic between competing British firms and hiving off interests from the airways corporations to private competitive airlines. Did the Minister not think, asked Mr. Beswick, that he would leave British aviation in a very poor position *vis-à-vis* European air transport operators?

In answer to these points, Mr. Harold Watkinson said that, from the information available, it was difficult to assess the probable impact of the merger proposal on British airlines, or how it might develop. For the time being, he thought it was right to keep an open mind about the British attitude. He did not agree with Mr. Beswick's other comments. For example, British European Airways had very close pooling arrangements with most of the European airlines, which were now adopting what might well be considered a rather sensible method of rationalisation of spares, maintenance, and so on. Hence, Britain's links with these arrangements were already very close. The present time was not at all the right one for saying that Britain's policies were necessarily wrong in regard to what was happening in Europe.

TELLING THEM ABOUT BRITAIN

A desire was expressed by Mr. Patrick Maitland (Conservative) that the Ministry of Transport and Civil Aviation should provide more inquiry desks at United Kingdom airports. He also considered that these desks should publicise promising factory locations likely to be of interest to industrial visitors from overseas.

Mr. John Hay, one of the Joint Parliamentary Secretaries to the Ministry, answered that London Airport was the only one which provided its own inquiry desk, and that desk was intended primarily to answer inquiries about aircraft movements. Information and publicity about factory sites was not available there, but inquiries on those points were referred to the Board of Trade or to the Federation of British Industries, as appropriate.

As to the situation in Scotland, the Scottish Tourist Office issued pamphlets once or twice a year drawing attention to industries in Scotland. The Board gave supplies of these pamphlets direct to the Ministry's airports in Scotland and, where possible, the pamphlets were displayed in passenger lounges. If it were apparent that there was a substantial demand for more facilities of this kind, he would certainly look into the matter.

Strontium 90 in the Stratosphere

Mr. Harold Macmillan, the Prime Minister, said that the General Advisory Committee to the United States Atomic Energy Commission had recently estimated that the stratosphere contains about 50 lb of strontium 90. He told Mr. Frank Allaun (Labour) that, according to the advice given to him, an estimate of this order was not inconsistent with the evidence; but the making of an accurate estimate was extremely difficult.

Preloaded Passenger Life Rafts

Experiments that have taken place in the construction and use of inflatable life rafts which can be filled with passengers before being made waterborne were referred to by Mr. S. S. Awbery (Labour). He was informed by Mr. John Hay that Ministry of Transport surveyors had witnessed two demonstrations of the launching of inflatable life rafts filled with passengers. The device employed was in an advanced stage of development, but certain details required further consideration. Other similar projects were also being developed.

Nothing Against Foreign Shipping

A suggestion was made by Mr. S. S. Awbery (Labour) that the British Government, in a certain instance, had taken discriminatory action against foreign shipping. Mr. John Hay informed Mr. Awbery that he knew of no such action taken by the Government and that a letter received from Mr. Awbery contained no details which would support such an allegation. The Government were, of course, strongly opposed to any discriminatory action against the shipping of other countries.

Landing Aircraft in Fog

Mr. Frank Beswick (Labour-Cooperative) asked about the landing of aircraft in foggy weather at London Airport with FIDO (Fog Intensive, Dispersal Of). He was told by Mr. John Hay that the Government were well aware of the importance of getting on with this development, but the trials of the new FIDO installation had not been progressing as successfully as had been hoped.

Solartron Translates New Knowledge

The growth of the Solartron Electronic Group since their foundation in 1948 by E. R. T. Ponsford and L. B. Copestick, is described in their latest annual review, characteristically entitled " New World We Are Building Now." The group employ over 1,300 people at five United Kingdom and several overseas locations. The original two-man nucleus has been expanded to a group board of experts, who control six specialised companies, each with their own establishment of scientists, engineers and technicians. Overseas there are four sales subsidiaries and five associate companies. Sales of the 125 items of proprietary equipment produced by the group exceed £2 million, of which one quarter is exported. The orders received during the year to June, 1958, represented a 52 per cent increase over the previous year. The order intake for the 12 months to April this year totalled £2·25 million.

The group's young chairman, Mr. John Bolton, sees their progress as something intimately related to the development of man's knowledge of his environment and his growing mastery of it. " Every day," he said, "we are turning new ideas into hardware, making new electronc systems—the impact of which is certain to engender a revolution in people's modes of thought and very existence." During the next five to seven years a five-fold increase in output is expected with only three or fourfold expansion of the numbers employed.

A new associated company, Solartron France SA is currently being formed. Already substantial orders have been booked and negotiations are in hand with a leading French manufacturer concerning the manufacture in France of certain types of Solartron precision electronic equipment. The group intend this company to enable them to meet the challenge of the Common Market. It represents a continuation of their policy to expand rapidly overseas, taking full economic advantage of zonal manufacturing or licensing arrangements where this may be appropriate.

For and Against Air Union

Two questions for Britain arise from the announcement that the air companies for the Common Market, except KLM, have formed themselves into an association originally known as Europair, but now called Air Union. How much trade will it take away from British European Airways? And will Air Union buy any British aircraft?

The first question was presumably considered very carefully by BEA before it decided not to join the new group. There seems little doubt, however, that the new pool will mean large savings in operating costs for its members. Air Union will have its headquarters in Paris (it might have been London) and will operate through four permanent committees. The first of these will deal with the coordination of development programmes which will involve cutting out wasteful competition.

The second will decide technical questions such as the type of aircraft to be used, and the best use of maintenance facilities. It is this committee which will decide what aircraft should go on Air Union's shopping list. At the moment the four companies have 334 aircraft between them, including Viscounts operated by Air France and Lufthansa. The signs are that for the longer hauls the Caravelle is going to be the most favoured aircraft. Air France have 24 Caravelles on order and it is likely that more will be bought for the pooled services.

The third Air Union committee deals with commercial agreements and the fourth with sales. The amalgamation of all sales offices throughout the world will in itself considerably reduce operating costs.

The agreement covers international flights only and not those inside each country or between the home country and its overseas territories. Even so, a considerable amount of traffic is involved including transatlantic flights, which will now be better spaced, and, when new types of aircraft come into operation next year, fewer in number. For a start, the four companies will keep their separate identities but at a later stage common capital investment programmes will be carried out. It has been stated that Air Union is not a closed shop and that other airlines can join after it has had time to settle down. It will be very interesting to see which companies take them up on this. Will BEA and KLM have second thoughts?

Pocket Gas Turbines

F. Perkins Limited are to manufacture a range of industrial gas turbines from 50 to 1,500 h.p. designed and developed by the Solar Aircraft Company of San Diego, California. They have acquired the whole of the share capital of Sugg-Solar of Westminster, who formerly held the licence from Solar to manufacture the Mars gas turbine. The acquired company's name has been changed to Perkins Gas Turbines Limited.

The agreement gives Perkins the rights to exclusive licences throughout Europe, Africa and the British Commonwealth, excluding Canada, to manufacture and sell all gas turbines developed by Solar. In addition they will act as sales representative for Solar gas turbines not in production at Peterborough. It is their intention initially to manufacture the Solar gas turbines in the 50 to 200 h.p. range and to market the 500 h.p. Jupiter engine and the new 1,250 Saturn from current production at San Diego. Manufacture of the 50 h.p. Mars engine has already started at Peterborough. More than 2,500 Mars gas turbines, which weigh only 98 lb with standard gearbox and all controls, have now been built by the American company. They have accumulated more than a million hours of operation in a variety of applications. These include portable pumps for fire fighting and industrial purposes, generating sets, compressors, smoke generators, shipboard deicing equipment and others. The first engines produced at Peterborough will be available for demonstration in these applications this autumn and orders are being taken now for delivery before the end of the year. The range of applications will be further extended next year when two additional Solar gas turbines—the 70 h.p. Titan and the 170 h.p. T-150—go into production.

In the United States Ford have developed a new gas turbine supercharged engine of 300 h.p. which weighs only one quarter of a truck diesel engine of comparable horsepower while its fuel economy rivals that of the diesel and is better than that of conventional petrol engines under most operating conditions. It has been under development for 2½ years. The Ford 704, as it is known, weighs 650 lb installed complete with all accessories built in and requiring only the addition of electrical power and fuel, of which a variety can be used. Ford expect to be testing the new engine in vehicles by the end of the year.

Ventilation Manifold

Two companies each with a long-standing connection with the shipping industry, have submitted a proposal for amalgamation to their shareholders. They are J. and E. Hall Limited, principally engaged in the manufacture of refrigerating machinery, and Thermotank Limited who are designers and manufacturers of all types of air conditioning equipment. The new company, which would be known as Hall-Thermotank Limited, would combine the design, technical and manufacturing resources of both organisations. Major gains are anticipated in the quality of service to customers, in considerable savings in costs and more rapid development of new ideas.

The Peninsular and Oriental Steam Navigation Company, who hold 52·3 per cent of the voting control of J. and E. Hall, would hold 35·1 per cent of the equity in the new group. Lord Dudley Gordon, the present chairman of J. and E. Hall, will be president of Hall-Thermotank Limited, the chairman will be Mr. I. M. Stewart, chairman of Thermotank Limited, and the deputy-chairman Mr. J. F. E. d'A. Willis, a director of J. and E. Hall Limited. Further strengthening of the group in the ventilation field will be obtained if the offer which has been made on behalf of the new company to the shareholders of Vent-Axia Limited is accepted. The proposal is to acquire all the ordinary stock of Vent-Axia at 10*s* 6*d* a unit. If the deal takes place Mr. J. C. Akester, chairman and managing director of Vent-Axia, will join the board of Hall-Thermotank. Over £4 million in cash and shares will be involved if the three-company merger takes place.

Steel Came to Jarrow

A private venture to alleviate severe industrial depression comes of age this month. It was 21 years ago, in 1938, that the late Sir John Jarvis, Bt., established—in a redundant boiler shop—a steel producing unit with the object of energising one of the worst hit areas of the thirties. Funds for the new works were provided jointly by the Treasury and by Sir John. Many hundreds of people were employed and new prosperity was injected into an area critically affected by a moribund shipbuilding industry.

The immediate success of the venture was due mainly to the quality of the equipment which was installed from the outset. Everything was new and of the most modern. The first cast of steel, for instance, was made in a 15 ton Tagliaferri three-phase arc furnace, by far the best equipment obtainable for the quantity of production envisaged. The tube works which formed part of the new shipbuilding organisation began production in the rotary piercer and pilger process. Since the official opening, Jarrow Metal Industries (now associated with Armstrong Whitworth (Metal Industries) Limited) have produced over 400,000 tons of steel for rolls, steel castings and ingots. Jarrow Tube Works (now a wholly-owned subsidiary of Tube Investments Limited) have in the same period produced 230,000 tons of not-finished tubes and some 33½ million feet of drawn tubes.

Today the steelworks remains one of the most up to date. It is equipped with three basic electric-arc furnaces with a melting capacity of 15 tons and has a research and inspection equipment which includes cobalt 60 isotope, electromagnetic and ultrasonic crack-detecting equipment. It is a tribute to its founder who evidently believed that a well equipped mill making quality products must succeed even in the depths of a slump.

Distributing Special Steels

The official opening last month of a new 5,000 sq. ft warehouse at Warstone Lane, Birmingham, marks the latest step in the progress of Thomas Millington and Company Limited who have been making special alloy steel since 1840. They were established at Harborne reservoir in Birmingham by their founder who came from Sheffield. In 1927 the company moved to Sheffield where they have their works and their research laboratories. For many years they have maintained warehouses in Birmingham and the new building is an attempt to cater more effectively for the needs of their Midlands customers, which have tended to become more complex over the years.

The new building embodies the most advanced practices in the handling of a wide range of products, and it is expected to enable the company to supply their customers with their precise requirements without any delay. The design of the building is unusually elegant and the facilities for quick service and easy loading are a great mprovement on normal warehousing practice.

Calling All Square Pegs

The BBC has put out a slender pamphlet drawing attention to its series of sound and television broadcasts on seeking jobs for young people. The importance of placing the right people in the right jobs certainly justifies using all media of explanation and persuasion.

The difficulties of presenting programmes of this kind are apparent. The temptation is to give a dramatic and hence idealised version of the career in question; otherwise by sticking strictly to the facts the programme may be dull. The real satisfactions of working are private and subtle and not easily conveyed. But even keeping to the facts has a certain merit for there is much confusion and misinformation on choosing a career and getting started in it.

The big contribution which the programmes can make is to create a climate of discussion. They will inevitably preach to the converted—the serious minded youngsters and their responsibly minded parents. But other households may be stirred to talk and even to think. These are the first steps in finding a congenial square hole for the typical young square peg.

Weapons Men

When the Atomic Weapons Research Establishment was recently opened to the press for the first time it became possible to take a closer look at two men whose names are intimately linked with the establishment's work. Sir William Penney, whose easy patient manner on that occasion and determination not to be evasive met a warm response, can be said to have created the establishment in its present form; while Dr. Nyman Levin, who earlier this year took over part of Sir William's responsibility as director of the Atomic Energy Authority's Weapons Group, will control its future.

Dr. Levin was born in 1906 and, like Sir William, was educated at the Imperial College of Science and Technology, after which he joined the Marconi company working on research and development from 1930 to 1940. From 1940 to 1955, he served with the Admiralty, and while with the Royal Naval Scientific Service was engaged on the development of microwave valves and very high frequency links. Later he was superintendent of the Admiralty Gunnery Establishment and head of the instrumentation group in the Admiralty Research Laboratory. From 1955 to 1958, he was chief of research and development to Rank Precision Industries where he was responsible for the development of Xerography in this country. Until his recent promotion to director, he has been deputy director of the Weapons Group since July 1958.

Sir William, who remains member for weapons of the Atomic Energy Authority and is to succeed Sir John Cockcroft as member for research, became director of the weapons establishment, Aldermaston, in 1953. He has superintended armament research for the Ministry of Supply, since 1946, after working some years on nuclear research in America, where he took part in the early development of atomic weapons.

After his return home he directed Britain's first atomic bomb test at the Monte Bello Islands, Australia, in 1952. When Sir Winston Churchill described to the House of Commons the results of that test, he told them that "the weapon behaved exactly as expected and forecast in many precise details by Dr. W. G. Penney, whose services were of the highest order." He was born in 1909, son of a Warrant Officer in the Royal Army Ordnance Corps, won a scholarship from Sheerness Technical School at the age of 17, took his B.Sc. and Ph.D. at Imperial College, and worked there and at Cambridge and the University of Wisconsin until the war.

His earlier studies had been concerned with the structure of metals and the magnetic properties of crystals. After his return to South Kensington he turned to nuclear physics and began to investigate the inner structure of the atom. Early in the war he was seconded to carry out scientific work for the Ministry of Home Security and the Admiralty, and spent some years on research into the nature of blast waves and the probable effect of various bombs and missiles. His work in this field was so outstanding that, as research on the atom bomb developed, the Americans asked for his services, and he joined the British team of experts in the United States and advised on the construction of the first atom bomb, exploded in the desert at Santa Fe. He went on to the Marianas where he helped to prepare for the bombing of Japan, and was one of the only two British observers who have seen the atom bomb used in war; he witnessed the Nagasaki bombing with Group-Captain G. L. Cheshire, V.C. After the war he helped to plan the Bikini test in the summer of 1946. The Americans were impressed at the time of the Bikini test when, although they had prepared a great deal of elaborate modern measuring equipment, some of the most important results were obtained by Dr. Penney with home-made apparatus. In the best tradition of the famous "sealing-wax and string" (Cavendish) Laboratory at Cambridge, he had assembled 300 old petrol cans and by filling them with water was able to register blast from various points on the atoll.

Sir William Penney has all his life been fond of outdoor sport, played football for various clubs as a young man, and lists among his recreations today cricket and golf, at which he has a handicap of eight. He once voiced his feelings about the development of the atom bomb in a broadcast which he ended with the words: "The energy and enthusiasm which have gone into the making of this new weapon stemmed essentially from the sober hope that it would bring us nearer to the day when World War is universally seen to be unthinkable."

Points in the Pyjama Game

One Sunday last month the International Ladies' Garment Workers' Union (80 per cent of its membership are women) took a twenty page insert (some of it in two and four colours) as an advertisement in the *New York Times*. They called it "Picture of a Union—the ILGU." Understandably the first article was called "The Problems of Success." No unsuccessful union would take out 20 pages in a New York Sunday paper.

As might be expected the supplement had everything in it. There was a short piece on management engineering (blessed and encouraged by the union), showing photography being used for work study on sewing. There were other articles, rather longer ones, on the union's old timers in the days when the garment workers of New York were one of the most sweated groups in the United States. The union clearly prides itself on being big, successful, inventive and restless. The American frontier has its spiritual descendants in other types of organisation than the big-business corporations.

The British trade unions have nothing quite comparable with either the flavour or the rumbustiousness of the ILGU. They wouldn't be British if they had. But they might take a leaf out of the American notebook and brighten up their public relations. However, the news that the National Union of General and Municipal Workers is to advertise for members on television is a start.

Tools Entail Responsibility

The 43rd session of the International Labour Conference held this month at Geneva has a modern look about it. Both the agenda and the delegations present reflect the changing times and the widening context which labour problems embrace today.

There will be tripartite observer delegations from Nigeria, Rhodesia and Nyasaland and the West Indies—all Federations within the Commonwealth. Today labour relations are becoming more sophisticated even in areas still emerging painfully from agrarian economies. The need to put better manual tools into the hands of West African peasants goes along with education of nascent trade unions into responsibility towards their members and the public, as well as a more acutely developed social conscience among managements.

In keeping with the times too is the appearance of radiation problems on the agenda. This year there will be discussions about protection of workers against radiation, collaboration between public authorities and employers' and workers' organisations at the industrial and national levels, and a general discussion about the problems of non-manual workers, including technicians.

Become an Engineer

A new booklet in the "Choice of Careers" series compiled by the Ministry of Labour (HMSO, 1*s* 9*d*) examines the opportunities for boys and girls in the engineering industry. Entitled *Professional Engineers*, the booklet reviews the very wide variety of jobs which are available to qualified engineers. It explains, in simple terms (supported by well chosen illustrations) how professional and practical engineers are trained, either by full-time or part-time study, sandwich courses and student or craft apprenticeships. There is a short description of the work that an engineer may do, including such areas as research, development, design, production planning, installation, inspection, maintenance and plant operation. Other chapters contain notes on the main branches—such as civil, electrical, municipal, structural, mechanical and aeronautical engineering—and on some aspects of the more specialised kinds.

The booklet, like the others in the series, is primarily intended to assist boys and girls about to leave school in considering their future employment. It will be of considerable assistance, however, to parents or teachers whose task it is to help in this choice. As stated in the booklet, "hardly any two engineers have exactly the same work and no brief study of engineering can do more than indicate some of the main features of the profession The lack of knowledge which exists in the teaching profession—and of course among parents who are non-engineers (particularly among professional people)—is so great that much of the shortage of qualified engineers can be attributed to it, at least in a major part. The publication of a good booklet is an admirable first step, but much more is needed to create understanding of what these opportunitues really mean and to break down the considerable prejudice which still exists in respect of careers in industry.

By Way of Encouragement

A new approach to personal incentives for shop floor workers has been devised by the managing director of a Durham firm. Its purpose is to improve productivity of individual hourly paid labour, by means of prizes awarded on the basis of "time keeping, attendance, earnings, efficiency, good work and cooperation." The company is Westool Limited, of St. Helens, Auckland, Co. Durham, and the man who worked out what is known as the "Help Yourself Game" is Mr. A. L. Hunking. Licensed and insured Vespa scooters will be given to the winner of each of three sections—machine shop, coil and transformer shop, and assembly shops. The scheme is being operated from 4 May to 11 July, and the leaders in the three groups will be posted at intervals throughout period.

NEW HORIZONS FOR SHIPS

By W. A. Crago, B.Sc., A.F.R.Ae.S., A.M.I.N.A.

Today, 12 June, HRH The Duke of Edinburgh "lays the keel" of the nuclear-powered submarine Dreadnought. In this article the Tank Superintendent of Saunders-Roe Limited, who are doing advanced experimental work on new ship designs (including the Hovercraft), discusses the prospects for improving merchant ships and shipping.

Before attempting to assess the future of British shipping and ship design it is essential to understand at least some of the problems which face the industry at the present time. Most of these problems are generated by what may be regarded as "unfair" competition—unfair because it is artificially induced.

One such problem comes under the heading of "flag discrimination." This results from trading agreements which specify that the transport of certain merchandise must be undertaken exclusively in ships of stated nationality. That such discrimination is widely prevalent is evident from the fact that well over half the countries with which we trade practice it in some form or other, and this obviously reduces the potential employment for British ships. Thus in the USA 50 per cent of American cargoes must be reserved for American ships. As a further example, India openly advocates acts of discrimination as a means of obtaining an expanse in tonnage.

Another problem results from the effects of subsidies obtained in some countries for their own shipbuilding and operation. In the USA particularly, these subsidies are vast, and of course result in the Defense Department exercising a control over design which will undoubtedly pay rich dividends in wartime but results in commercially inefficient ships. This, naturally, is one of the factors which helps to create the necessity for American flag discrimination. Government subsidies on the construction of the "United States" amounted to 60 per cent of the total cost, while a contribution to operating expenses may be obtained by the American operator of up to £3,500 per day. France is reputed to be subsidising a £32,000,000 liner to the extent of £7,000,000, and similar subsidies are reported from Italy. No such assistance is available in Great Britain although certain taxation allowances are made with regard to investment.

Yet a further artificially induced disadvantage forced on British operators is the advent of "flags of convenience." At the end of 1958 the tonnage registered in Panama, Liberia and Honduras amounted to 15¾ millions (about 14 per cent of the world total). Unlike ships registered in this country, much of this shipping virtually does not pay tax.

One source of the difficulties briefly outlined above is the understandable spirit of nationalism in new or rapidly developing countries. Such countries want their own merchant marine and often use artificial rather than economic means to achieve this end.

All these problems have been growing in importance for some time, but today they mean that the British operator is faced not only with the competition of efficient ships of other long-established maritime nations, but also with subsidised and non-tax-paying ships. And all this in a world where there are fewer cargoes to be had as a result of discrimination. The unfortunate but inevitable result is the necessity of laying up a proportion of British ships for which no work can be found.

A further feature which must obviously aggravate the situation is the increasing number of ships being built. Thus the report of the Chamber of Shipping of the United Kingdom for 1958-59 shows that there are 114 million gross tons of shipping in the world today. A year ago the figure was 107 millions, so even in such a short space of time a further 7 million tons have been brought into being to compete with existing British ships which have already had their potential market contracted by the various means already described. Obviously the older and more inefficient ships will be laid up first and with the present low prices of scrap and the high cost of recommissioning, many of them may well stay laid up—a mute testimony to the world's willingness to sacrifice economy and good business to security and national pride.

In my view, national self-sufficiency in shipping must inevitably lead to needless duplication and is therefore an unstable situation. Either we shall see a return to a common sense attitude where the best tender gets the job, or shipping as a commercial enterprise will eventually cease to exist and will have to be replaced by nationalised ventures.

Yet another problem is competition from the aeroplane. Three-quarters of the world's trade moves by sea, but in the most lucrative places the aeroplane has established a tremendous beach head—particularly of course in passenger transport. For instance the number of passengers travelling over the Atlantic by air in 1958, exceeded those travelling by ship for the first time. This fact must be tempered by the realisation that the aircraft has probably created its own business to a large extent and also that the aircraft benefits from large hidden subsidies.

Soon the new giant jet airliners will swell the total number of aircraft designed for the Atlantic journey. Since one such aircraft will be able to shuttle 30,000 economy passengers across the Atlantic a year, this in theory means that 70 such aircraft could have catered for all the Atlantic passengers (both ship borne and airborne) last year. It appears unlikely that the airlines will be able to create a great increase in passenger traffic, which suggests that the Atlantic aircraft will be operating much less efficiently in the future—and will need bigger subsidies. As a result, British shipping companies may justly regard the existence of the airlines as yet another example of unfair competition.

There are obvious short-term answers to all the problems I have mentioned so far. Increased British tax relief, an internationally agreed and more equitable shipping policy, an international trade union against flags of convenience or the nationalisation or heavy subsidisation of the shipping industry are all possible answers. However, the existence of this growing problem in ship economics can only be properly and safely answered by a really significant increase in operating and building efficiency—and this can only be achieved as a result of research.

I believe the money invested in marine research in this country has been insufficient and, compared with the research investment in the aircraft industry, is pitifully so. Although the soundness of the economics of air travel across the Atlantic may be in doubt, there is no question about the long technical strides that have been made in the aircraft business. The same order of massive investment in research must be applied to the shipping industry. After all, it is very fitting that new strides forward in ship design, operation and construction should be made in this country, with its traditional interest in—and dependence upon—the sea.

There are of course a number of different fields for possible technical improvement in ship design and operation. Each has already benefited from applied research but further progress is obviously necessary. This progress could well be startling if the order of research were stepped up.

Hull Form

Any reduction in hull resistance that can be achieved will be reflected in a corresponding reduction in the horse-power required to maintain a given speed. Such a reduction implies a smaller fuel bill and is clearly well worth pursuing.

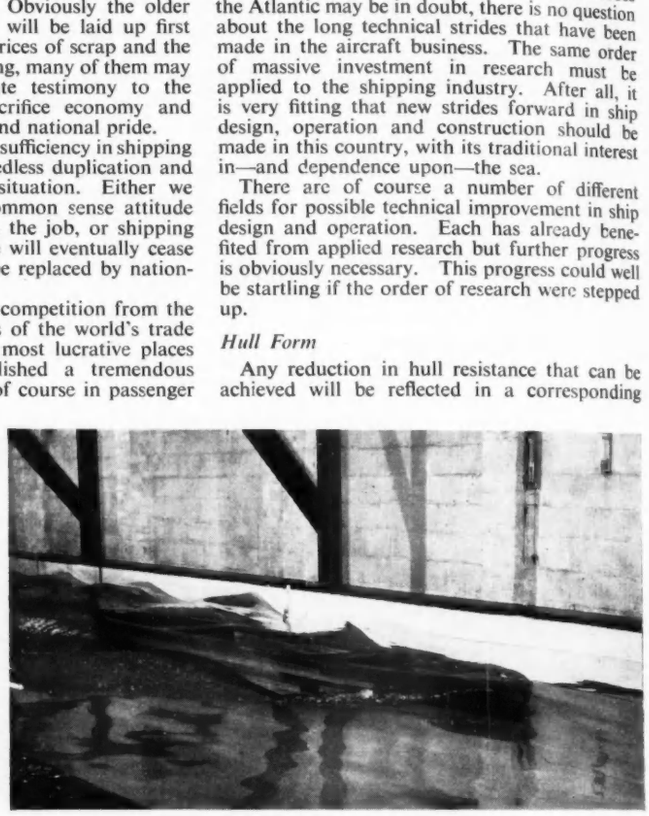


Fig. 1 A model running in the Saunders-Roe No. 2 Tank showing the characteristic wave formation for a $V/\sqrt{L}$ value of 0·9, corresponding to a "hollow" in the resistance curve.

The hydrodynamic resistance of a ship is made up of wavemaking resistance and the rest is mainly due to skin friction and roughness. The wavemaking resistance may be considered as being generated by two point disturbances located near the bow and the stern, as illustrated by Fig. 1. The length of the waves generated by the point sources are proportional to the square of the velocity, and so there will be certain speeds where the waves will tend to cancel each other out, and others where they will add together. As a result, the resistance curve will alternatively show a hump and a hollow.

Fig. 2 shows the two major components of the total resistance (exaggerated) plotted against $V/\sqrt{L}$ so that the curves apply approximately to all lengths of hull.

It will be readily appreciated that it does not pay to design a ship that operates at point A on the curve, while point B is a good point at which to operate. Incidentally this curve readily affords a criterion to assess whether any given Atlantic liner is built for prestige or profit.

Various methods of partially suppressing the waves generated by the hull have been suggested in an attempt to reduce the energy normally expended in generating them. The hydrofoil craft, for example, makes very little wash, but it seems most unlikely that large ships will ever be supported by hydrofoils because of the way that the hydrofoil weight penalty rises so quickly with total weight.

However, there are other methods of reducing

the waves by suitably shaping the hull. Surprisingly little has been done in this direction so far. Undoubtedly one reason is that an optimum hull shape designed for minimum wave drag would not have a parallel middle body and the resistance reduction would have to be balanced against the increased cost of construction, the loss of cubic capacity and ease of stowage. But, as the quest for greater efficiency becomes more pressing, such optimum hulls will undoubtedly be designed. The derivation of their shape will be assisted by the use of high speed digital computors in conjunction with such mathematical expedients as replacing the ship hull with a system of hydrodynamic sources and sinks.

A more revolutionary approach to the problem of suppressing the wave making resistance is the proposal to employ submarine cargo ships. If the submarine is immersed sufficiently deeply below the water surface no surface waves are generated. Of course the wetted area is approximately doubled and this means that the submarine's resistance curve will lie above the surface ships' skin friction line and at about twice the height above the velocity axis. It follows that at low speed the submarine will have a higher resistance than the surface ship—but at higher speeds the submarine will have the advantage.

It has been suggested that the boundary layer flow around the hull can be made laminar

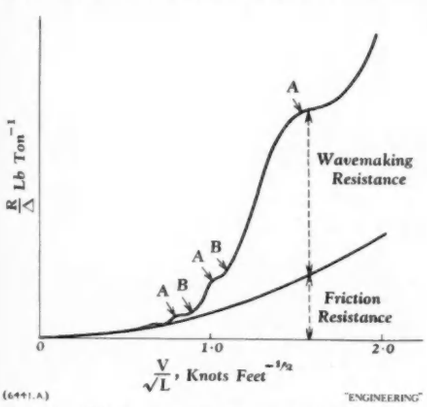


Fig. 2 Ship resistance characteristics ("humps" and "hollows" exaggerated).

instead of turbulent in order to reduce the skin friction but the practical problems involved are rather overwhelming.

A practical method of reducing both the major components of the resistance is to exploit the advantages of the large ship. Doubling the length of a hull while maintaining the same speed reduces the value of $V/\sqrt{L}$ by a factor of $\sqrt{2}$. Reference to Fig. 2 shows that the resistance per ton will be reduced. This reasoning has led to the advent of the super-tanker, and more recently of "super-super" tankers having deadweights up to 100,000 tons, but such mammoth ships require large and expensive port facilities. Apart from the fear of the unknown, however, there seems no technical reason why—if necessary—tanker and port sizes should not grow even larger than they are at the moment.

A feature of recent approaches to the problem of ship performance is the recognition that the sea is never ideally calm and that the hull should be designed to have good characteristics in waves. Normally, as increasingly larger waves are encountered, a ship first slows down because of the increased effective resistance. Eventually, however, the speed has to be reduced deliberately in order to avoid damage to the ship, cargo or passengers because of the excessive motion. Roll stabilising fins have already made a contribution to the reduction of rolling motion and it is entirely possible that similar principles will be applied to alleviate pitching motion and hence allow speeds to be maintained under bad weather conditions.

The theoretical and design problems involved in reducing the severity of ship motion in waves have been more clearly defined because of the work of oceanographers who have in recent years found out how to represent apparently random seas in mathematical terms. Much more emphasis on this approach to ship design may be expected in the future.

Machinery

Various possible forms of motive power will be available for installation in the ships of the future. Nuclear power, diesel, steam turbines and free-piston installations are already available. While nuclear power does not yet constitute a threat to the others, the advances made in relatively few years (as the result of a tremendous research investment) suggests that progress in the future may be even more rapid. At the present time it would appear that the capital cost per horse-power falls more rapidly with increase of power for nuclear installations than with orthodox machinery. Thus the first economic installations are likely to be in cases where high power outputs are required.

More orthodox installations will of course still be used where lower outputs are required. Steam installations are not likely to be improved much more than they are at present. The diesel engine no doubt has a considerable development potential but it may be out-moded quite soon by the free-piston system which requires less space and has a smaller weight penalty. It is also regarded as being more flexible in application and of course the diesel vibration is eliminated.

Construction

What improvements can be expected in the field of construction? First, as regards materials there is no doubt that aluminium and its alloys will find an increasing application, particularly for the superstructure of the ship.

This will be in an attempt to reduce the ship's displacement still further. Weight saving is directly reflected in the saving of horse-power and hence fuel.

If the type of weight control that is necessarily exercised in the aircraft industry is applied to the design and construction of the ship then very much greater savings will be made. This is a very promising field for investigation and exploitation.

Moulded glass-fibre reinforced plastics will be used more and more for small components in big ships and also for hulls of light craft. Allied to the increased use of new materials we can expect improved methods of handling and a greater use of the principle of prefabrication in order to reduce costs.

Operational Techniques

The increasingly competitive nature of transport by sea has already meant that considerable attention has been given to the possibility of increasing operational efficiency. This is determined by a conglomeration of small things such as cargo handling, navigation, application of advanced radar, avoidance of bad weather and so on.

With some classes of ship, cargo handling has already advanced to the stage where it is difficult to see how improvements can be made. Thus a 30,000 ton tanker can completely discharge its oil and take on water ballast in 24 hours. A quicker turn-round can be envisaged but would deprive the crew still further of the chance to get ashore and it might then become difficult to get people to work the ships. In the case of dry cargo ships, on average, the time spent in port is longer than the time spent on the journey. Obviously a speed-up is required here. The concept of pre-packaged cargoes which can be handled easily and quickly is extremely attractive.

It is obvious that the avoidance of bad weather (when possible) will increase the operational efficiency of any ship. Of recent years this elementary concept has been put on a thoroughly scientific basis and it has proved possible to employ long-range wave forecasting and use computers to predict the best course to be followed in order to reduce the possibility of cargo damage or passenger discomfort and also to give the shortest passage time and best fuel consumption.

American results averaged over the Atlantic and the Pacific have shown that from 10 to 20 hours per journey can be saved.

Rules, Regulations, Traditions and Superstitions

When a ship is designed, it must be decided how strong to make the various parts of the structure. In practice, this decision is not generally made by direct calculation; a set of rules is referred to. These rules are based partly on theoretical knowledge and partly on experience. The use of such rules results in a ship which, except in very exceptional circumstances, is strong enough for the job it has to do. However, the question may be asked—is the ship, or some of its components at least, very much over-strong? Clearly overall efficiency may be increased by the relaxation of such rules while maintaining adequate strength.

The design of a ship is also influenced by the tonnage regulations. Port and canal dues—to mention only a few—are determined largely by the cargo-carrying capacity of the ship. But this capacity is calculated in what is an arbitrary and artificial manner, so the designer—in taking advantage of the loopholes in the method of

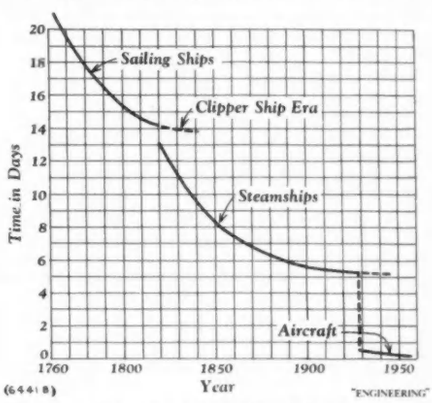


Fig. 3 Time to cross the Atlantic. (From Sir Arthur Gouge's Wilbur Wright Memorial Lecture to the Royal Aeronautical Society, 1948).

assessment—is forced to distort the ship. This has led to the building of certain ships where it is true to say that the greater the safeguard against unseaworthiness, the greater the penalty incurred in respect of the tonnage. A more realistic assessment would obviously remove such a dangerous anomaly.

These are some possible improvements in orthodox ship design. There are, however, current experiments which may result in entirely new concepts being developed. One such new development is Saunders-Roe's "Hovercraft." The prototype craft has been successfully flown and the designers are confident that the principle can be used on much larger craft. In fact, Hovercraft weighing thousands of tons and moving at speeds of about 100 knots are envisaged.

Briefly, the principle is that the craft is supported on a cushion of air and skims over the surface of the sea. It can be loaded and serviced on land, making harbours and expensive port facilities unnecessary. Both in conception and operation it fills the gap between aircraft flying fast with comparatively small payloads and large-capacity ships travelling at low speeds.

It is the writer's firm conviction that a considerable research investment is necessary in order to cope not only with the present artificially induced though none the less vital problems facing the British shipping industry but also to meet the challenge of the future. A new break-through may give us a new curve to add to Fig. 3.

Fast Particles

ALL nuclear processes will be better understood when the forces that bind the atomic nucleus together have been elucidated. They appear to be very complex and the spectrograph of aluminium, for example, could be used to paper a sizeable room. A major technique in the investigation of these forces involves the bombardment of nuclei using charged or neutral particles. Being uncharged neutrons may approach a target nucleus more readily, even when travelling slowly, since they are not subject to repulsive forces, but charged particles, such as protons, electrons, and ionised nuclei, can, on the other hand, be accelerated to controlled high velocities by means of accelerating machines. Neutrons produced in nuclear reactors may be used as the bombarding agent, but they are emitted with a random distribution of energies. Fortunately, neutrons of known velocities, particularly fast neutrons, may be produced indirectly by particle accelerators as the result of an interaction between an accelerated charged particle and a primary target. Much work remains to be carried out, and to this end machines ranging in potentiality from a few hundred keV, through MeV energies to the GeV capacities of the large synchrotrons, are being built. Recent news of particle accelerators and other experimental work is reviewed below, and particular reference is made to studies at the Atomic Weapons Research Establishment, Aldermaston, where a new tandem Van de Graaff machine has recently come into operation.

Research at Aldermaston

The Nuclear Physics Research Division at Aldermaston was only formed as such in 1955. Its primary function was to obtain certain technical data that were required for the Weapons Project. So that these nuclear quantities could be measured, it was necessary to set up several machines for achieving nuclear transmutations, and for following the course of nuclear reactions in fine detail. Such facilities are flexible, and enable a large variety of nuclear measurements to be made.

Accelerators Operated by AWRE

In the Nuclear Physics Division at Aldermaston there are the following nuclear machines. (1) A 6 MeV electrostatic generator made by the High Voltage Corporation, Cambridge, Mass., capable of giving up to 60 μA of protons, deuterons or alpha particles at 6 MeV energy, stablised to within $\pm$ 2 kV. (2) A 3 MeV electrostatic generator, made by the same company, capable of giving up to 60 μA of protons, deuterons or alpha particles at 3 MeV energy, stabilised to within $\pm$ 1 kV. (3) A new 12 MeV tandem electrostatic generator, designed by AWRE in collaboration with AERE, Harwell, and with Metropolitan-Vickers Electrical Company Limited. (4) An 800 kV Cockcroft-Walton machine. The first three machines employ the Van de Graaff principle, whereby electric charge is carried by a continuous belt to a dome.

Electrostatic Generator: Principle

It is the function of an electrostatic generator to produce a directed beam of charged particles; the beam current would be many microamperes and the energy controllable. A Van de Graaff machine devised for this purpose is shown diagrammatically in Fig. 1. The required nuclei are initially obtained from the appropriate gas. Thus protons, deuterons and alpha particles are derived respectively from hydrogen, heavy hydrogen or helium gas. For protons, the hydrogen gas is led into a small vessel at low pressure ($\sim 10^{-2}$ mm Hg) and ionised by a radiofrequency discharge. The protons are directed through the exit canal in the ion source by a positive voltage of about 2 kV. After suitable focusing, they enter a long evacuated accelerating tube in which the pressure is maintained at about 10^{-5} mm by high-speed diffusion pumps. To the tube is applied a stabilised voltage of several million volts, positive at the ion source end, and earthed at the other end, and this voltage seems to accelerate the positive protons to the required energy. They emerge at the other end, into an evacuated tube (evacuated as protons are scattered and slowed down by air).

The voltage is produced by an electrostatic process or Van de Graaff principle. An endless belt is rotated at high speed within the length of an insulated stack. At the top of the stack is a polished dome—the top terminal—which contains the ion source and associated power packs. Near the belt, at the lower earthed end of the stack is placed a comb, from which by an inductive process, a continuous corona discharge takes place onto the belt, which acquires a positive charge. The charge is carried to the top terminal, where it is removed by a wire gauze. Thus the top terminal, which carries the acquired charge on its outer surface and is therefore electrically neutral inside, becomes positively charged. If there were no mechanism to remove the charge, the dome would rise in voltage until it sparked to neighbouring earthed surfaces. In practice, the charge is drained slowly to earth down a high-resistance chain running the length of the stack, and the top terminal rises to a controllable steady high voltage determined by the current sprayed on to the belt. This voltage will accelerate the ions produced in the source (thus additionally using up some of the sprayed on current). The power supply for the ion source is of course at a potential of several million volts, and so can be supplied only by means of an alternator belt driven by a motor at the base of the machine. Equipment within the top terminal is remotely controlled by long insulated strings. To enable the equipment to be of reasonable size without sparking over, it is built into a large pressurised tank. The emerging proton beam is passed through a "resolving magnetic field." The field bends the beam through different angles, according to the particle energy. Thus unwanted particles arising from ion source impurities may be rejected, and the beam, passing through a narrow slit after deflection, is well defined in energy. By amplifying the rejected current striking either side of this slit, and feeding the difference signal back to the generator, any fluctuation of voltage can be stabilised. The maximum voltage that can be reached in a system of reasonable size is about 6 MV, and the stability attainable is about 2 kV.

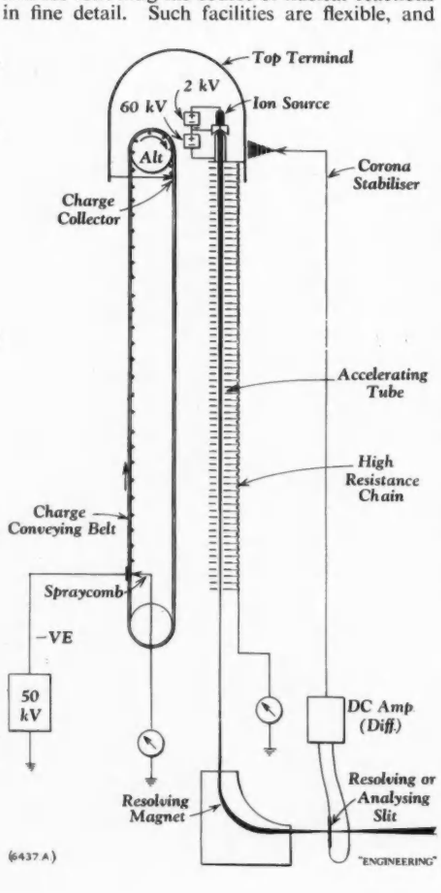


Fig. 1 (left) Diagram of 6 MeV pressurised Van de Graaff accelerator, omitting pressure tank.

Fig. 2 (right) Diagram of tandem accelerator.

The ion source injects negative ions into upper tube, via pre-accelerating tube, and is at a negative potential variable from 20 to 120 kV.

The low energy accelerating tube accepts negative ions at injection energy and accelerates them to an energy corresponding to the high tension terminal voltage.

The high tension terminal at potential V may be varied from 1 to 6 MV positive with respect to earth.

The stripper is essentially a narrow bore tube containing oxygen at relatively high pressure (20μ Hg) and serves to remove electrons, thereby allowing positive ions of V electron volts energy to enter the high energy accelerating tube and so fall through a further V volts to acquire a total energy of 2 V electron volts.

The high energy accelerating tube accelerates protons to energy 2V.

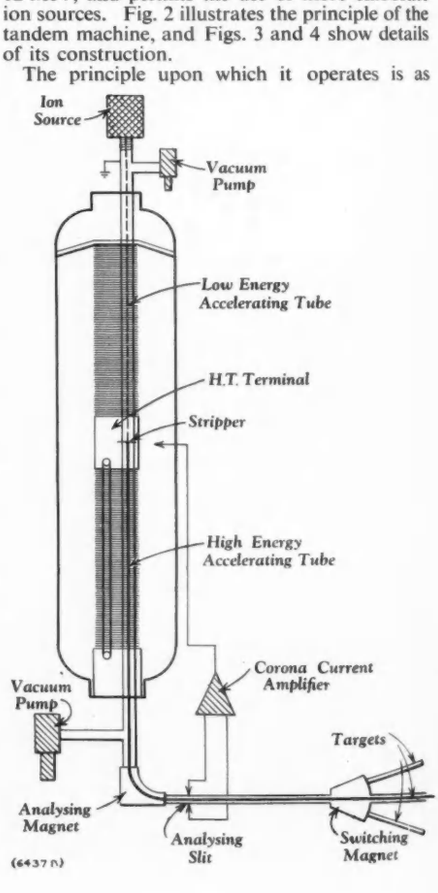
Electrostatic Generator: Virtues and Defects

The great advantage of the electrostatic generator is the ease with which well-stabilised energies up to 6 MeV may be reached, at reasonable cost. The disadvantages arise from the need to pressurise a system in which the complex ion source, with its associated equipment, is at such high voltages. Because of this, the ion source and other equipment must be made quite small, to fit into a relatively small top terminal, and access to it is difficult if servicing is needed. These difficulties no longer hold in the tandem electrostatic generator. A further difficulty is common to all electrostatic machines—the attainable current (including that draining down the resistor chain) is limited to a few hundred microamps.

Tandem Generator: Principle

The tandem generator, which is a modification of the electrostatic generator, gives microampere beams of charged particles of energies up to 12 MeV, and permits the use of more elaborate ion sources. Fig. 2 illustrates the principle of the tandem machine, and Figs. 3 and 4 show details of its construction.

The principle upon which it operates is as



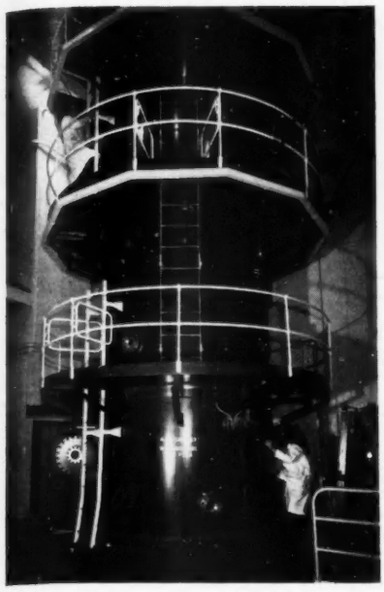


Fig. 3 Pressure vessel (45 ft high by 9 ft internal diameter) for the MeV tandem electrostatic generator at AWRE. It contains a pressure of 200 lb per sq. in.

Fig. 4 (left) Inside view of pressure vessel for AWRE tandem electrostatic generator. Provision has been made for the acceleration of heavy ions.

Fig. 5 (above) Injector for the AWRE tandem machine, showing the negative ion source.

follows. If a neutral hydrogen atom is travelling relatively slowly (less than 50 to 100 keV) and passes through a gas, an electron associated with an atom in the gas may become attached to the hydrogen atom, giving a negative hydrogen ion, H^-. This acquisitive tendency is so high at low energies that a positive hydrogen ion can even be transformed into a negative ion by the double capture of electrons. If the speed of the atom or ion is increased much above 100 keV, the "sticking probability" becomes very much less, and the probability of the converse process (double electron loss converting H^- to H^+) becomes quite high—that is, at low ion speeds an electron sticks easily, while at high ion speeds, an electron is knocked off easily. If a beam of low-energy negative hydrogen ions is injected into one end of an accelerating tube earthed at both ends with a potential of (say) + 6 MV at its middle, the negative ions will be accelerated to an energy of 6 MeV at the centre of the tube. It a thin foil or a tube containing gas at low pressure is placed at this point, most of the H^- ions will be stripped of electrons and converted to H^+ ions or neutral atoms. The neutral atoms drift on at 6 MeV without acquiring more energy, but the stripped ions, now positive, are further accelerated down the second half of the tube to reach a total energy of 12 MeV at the bottom. In this way controllable energies up to 12 MeV may be achieved by means of voltages no higher than 6 MV.

Features of the AWRE Tandem Generator

In the AWRE tandem, the negative ions are produced in a large ion source, shown in Fig. 5 located outside the top of a pressurised tank (built by John Thompson Limited), down the length of which runs the evacuated accelerating tube into which the ions are introduced. An electrostatic generator runs up the lower half of the stack, so that the half-way point can achieve voltages of up to + 6 MV. Inside the vacuum tube at this point is placed a "stripper" comprising a tube of $\frac{3}{16}$ in internal diameter and 24 in long, into which gas is continually allowed to stream at a rate of 5 cu. cm per hour. By pumping hard at either end of the tube, it is possible to preserve the vacuum in the main tube at between 5×10^{-5} mm and 5×10^{-6} mm, while the pressure in the stripper is kept at an average of 0·02 mm. This concentration of gas, while retarding the fast ions by only an insignificant amount of energy, is sufficient to strip the greater proportion of them and convert them to positive ions. The beam emerging from the negative ion source is focused before entering the accelerating tube, so that the majority of the beam enters the narrow stripper tube, and the beam emerging from the stripper is further accelerated. After leaving the machine the particles are passed, as in the simpler machine, through a beam bending magnet and hence to the flight tubes (Fig. 6). Experiments are at present being carried out at an energy of up to 10·3 MeV. Fig. 7 shows a proton beam.

Tandem Generator: Advantages

The advantages of the tandem generator are as follows. (1) Although the electric potential produced is only 6 MV, 12 MeV controllable energy is achieved. Such energies have hitherto

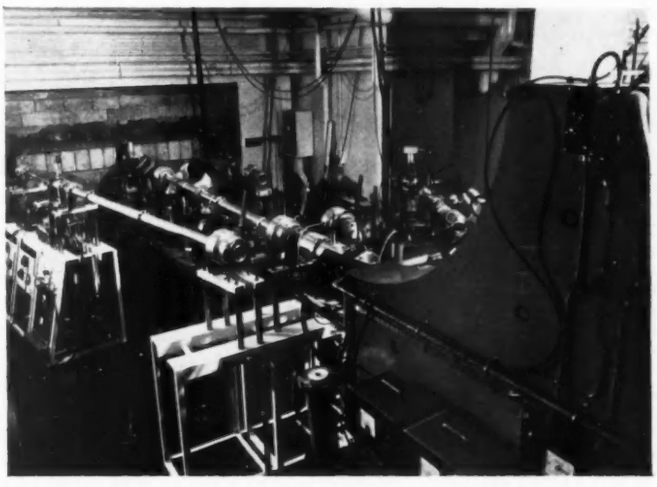


Fig. 6 (right) Layout of experimental floor with beam bending magnet (right) and flight tubes.

Fig. 7 (below) A 10·5 MeV proton beam seen emerging through a thin nickel foil into the air.

been attainable only in cyclotrons, the energy of which cannot easily be varied. Thus for the first time beams of charged particles are available with controllable energy up to 12 MeV. (2) The ion source being at earth potential can be built outside the tube, and so be made on a much more elaborate scale than that of an orthodox Van de Graaff generator. Thus the eleborate focusing mechanism necessary to steer the beam into the stripper can be made without undue difficulty. Also, the ion source can be readily serviced.

Electrostatic Generators as Neutron Sources

Each of the three electrostatic generators can be used as neutron sources. The beam of accelerated protons (Fig. 7) or deuterons is led through a vacuum tube to a target of tritium or deuterium, where one of the following reactions takes place:

$$T + p \rightarrow He^3 + n - 0{\cdot}764 \text{ MeV}$$
$$T + d \rightarrow \alpha + n + 17{\cdot}6 \text{ MeV}$$
$$D + d \rightarrow He^3 + n + 3{\cdot}265 \text{ MeV}.$$

The neutrons emerge through the walls of the tube, which they penetrate quite easily, being uncharged. The energy which they possess depends on the incident particle energy and the angle of emission relative to that of the irradiated particle. The following table shows the attainable neutron energies in MeV.

Ed (MeV)	Tp	Dd	Td
0	—	2·47	14·07
3	0·38—2·21	1·63—6·27	11·83—19·58
6	1·12—5·23	1·69—9·21	11·65—23·11
12	2·59—11·22	1·98—14·97	11·97—29·37

Thus even with the 6 MeV machine, a valuable range of energies may be covered, while the tandem machine makes it possible to explore a range of neutron energies without any gaps. Neutrons, being uncharged, reach the walls of the laboratory, from which they are reflected and form a troublesome background. To minimise this effect, all AWRE neutron experiments are conducted on the first floor of the buildings—the beam is led out over a thin checker-plate floor, and the neutron source itself is so situated that the nearest substantial wall, or floor, is at least 10 ft away. Charged particle experiments are not subject to this requirement, and so are conducted on the ground floor of each building.

Cockcroft Walton Machine as Neutron Source

In order to give a strong source of 14 MeV neutrons, the very high yield of the Td reaction at low energies (~ 200 to 800 keV) is exploited. To do this, an 800 keV machine is used similar to that originally used by Cockcroft and Walton in 1937 and made at AWRE using an electrical generator constructed by Philips of Eindhoven. It is capable of giving up to $\frac{3}{4}$ mA of deuterons and the voltage is stable to within $\pm$ 2 keV. With suitable choice of tritium target, source strengths up to 10^{10} 14 MeV neutrons per second can be achieved.

Neutron Spectrometry

Many of the experiments undertaken involve the measurement of a neutron spectrum; that is to say, nuclear reactions are induced using neutrons of a given energy, and the different energies with which neutrons are emitted from a given reaction are determined. It is quite difficult to construct a neutron detector which readily distinguishes between neutrons of not very different energies, say 2 and 4 MeV, since neutrons can only be detected by the secondary charged particles they produce. However, it is possible to distinguish the speeds at which neutrons of different energies travel. The table shows the time taken for neutrons of different energies to travel 1 metre.

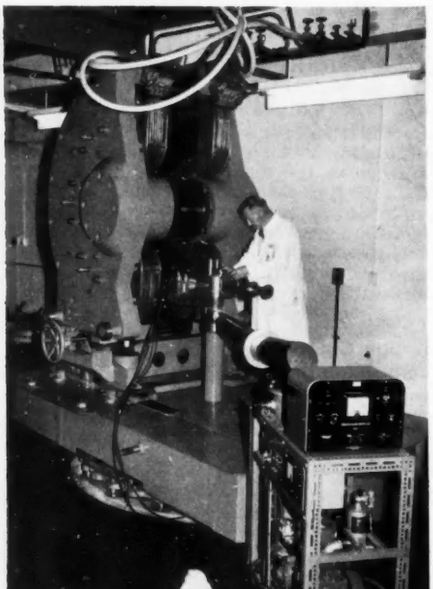
En (MeV)	0·5	1	2	4	8	14	(light)
Time (10^{-9} sec.)	102	72·3	51	36·1	25·5	19·3	3·3

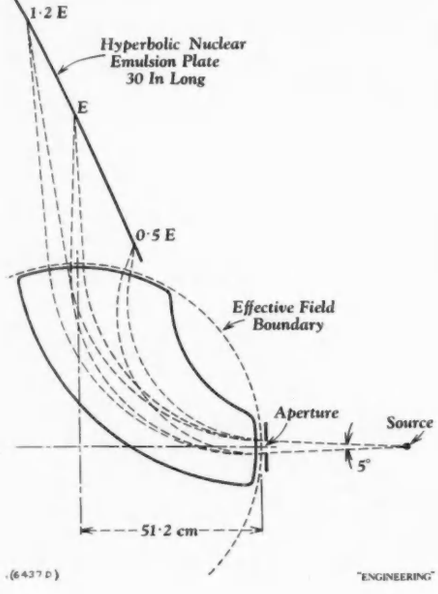
Time of Flight Spectrometer

The time of flight spectrometer exploits the distinguishable speed property. Consider the Td reaction. The incident deuterons pass through a pair of deflector plates to which a radio-frequency field of 2·5 Mc per sec is applied. Thus the beam oscillates up and down with this frequency; immediately after the r.f. deflector plates is placed a narrow slit, across which the deuteron beam passes twice every cycle, so that a burst of deuterons carries on to the tritium target every 200 mμsec, approximately 5 mμsec long. Thus a pulse of neutrons of this duration and frequency is emitted from the target. Near the target is placed a specimen of the substance the nucleus of which is being examined, and the counter is placed, say, 1 metre away. Suppose that under bombardment the nucleus under examination emits neutrons, of energies 4, 2 and 1 MeV. Then at the counter, we observe pulses at 3·3 mμsec after each burst (corresponding to gamma rays from the target) at 19·3 mμsec (corresponding to undegraded neutrons) and at 36·1 mμsec, at 51, and at 72·3 mμsec respectively, corresponding to the degraded neutrons; these energies are therefore determinable. The energy resolution thereby achieved depends on the length of the incident pulse, and is also dependent on the energy of the neutrons being studied, since it is obviously better at low energies. Thus, with the conditions mentioned, a 14 MeV neutron can only just be distinguished from an 8 MeV neutron, while a 2 MeV neutron can be distinguished from a 1·6 MeV neutron.

Charged Particle Analysis

In certain experiments, the charged particles emitted when a nucleus is bombarded with other





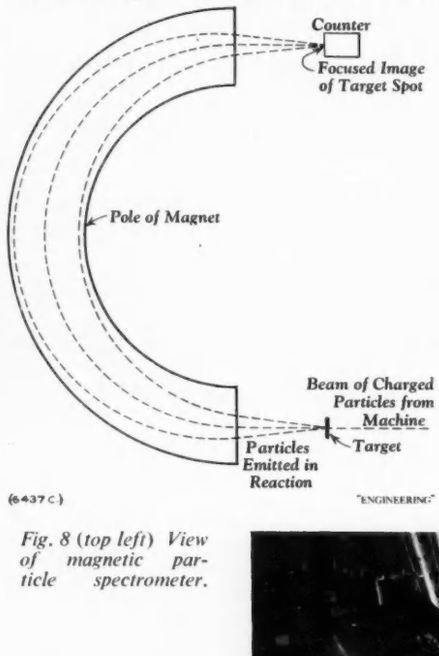


Fig. 8 (top left) View of magnetic particle spectrometer.

Fig. 9 (above) Principle of magnetic particle spectrometer.

Fig. 10 (left) Principle of magnetic particle spectrograph.

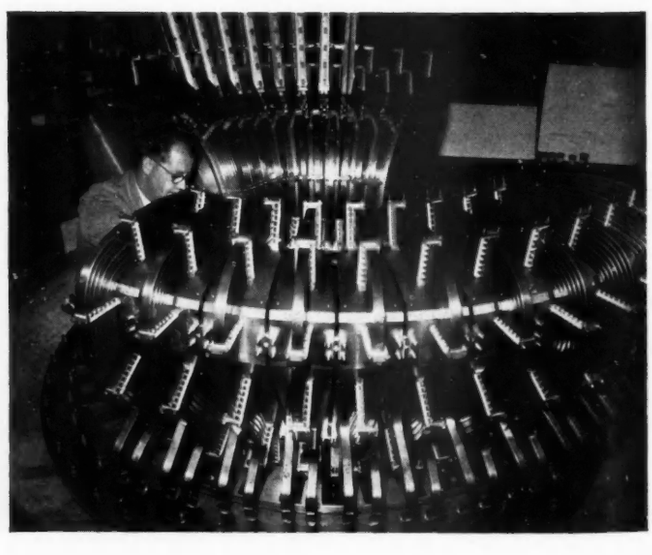


Fig. 11 (right) Multi-channel spectrograph during assembly.

charged particles are examined. The incident charged particle beam is led down an evacuated tube, to a target chamber, containing the specimen. The charged particles, emitted within a vacuum, are examined in terms of the direction of emission, so providing spectrum information. Unlike neutrons, charged particles of different speeds may readily be distinguished from each other by the angles through which they are deflected in a magnetic field. More precisely, if a particle, mass m, energy E, charge e, enters a field H, it is bent into a circular path of radius ρ where $\rho = \frac{\sqrt{2mE}}{H}\frac{c}{e}$ (c is the velocity of light). Typically, 20 MeV protons have a turning radius of about 24 in in a field of 10,000 gauss. Thus, to distinguish magnetically between the energies of particles emitted in nuclear reactions, it is necessary to build large electromagnets.

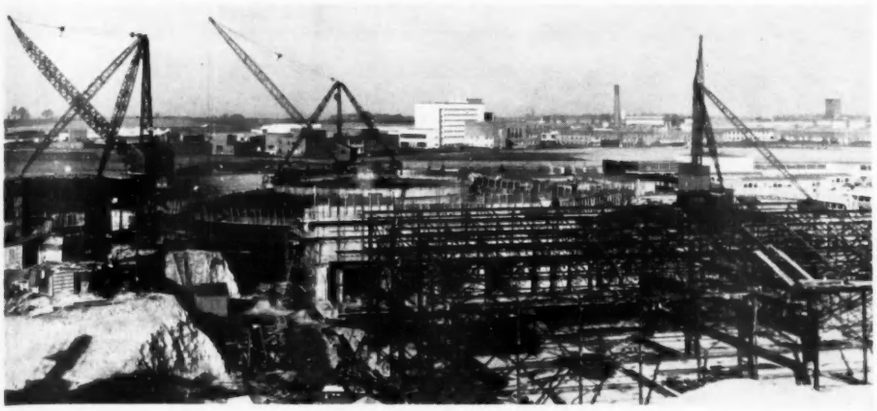


Fig. 12 View of the site where the 7 GeV proton synchrotron Nimrod is being built near Harwell.

Focusing

Another requirement that must be met is that of focusing. To observe a reasonable number of emitted particles in the experimental time, the magnet must receive, not just those particles emitted in one direction, but those emitted in a small but definite solid angle about this direction. All particles within this solid angle must be brought converging to a spot where the detector is placed. The magnet must produce an "image" of the target, rather like an optical lens or rather, since it is dispersive, to a pair of lenses and a prism. Just as in an optical lens, the image is not perfect, but is blurred by aberrations, and the bigger the solid angle the magnet accepts, the greater the blurring of the image, and the larger the energy difference ΔE between particles whose energy can only just be resolved. This determines the so-called resolving power of the magnet, $E/\Delta E$.

Spectrometry and Spectrography

A magnet can be designed to do one of two things. It may (*a*) bring particles of a given energy to focus at a counter placed at a definite point, as shown in Figs. 8 and 9. This observed energy can be varied, by altering the magnetic field (that is by altering the energising current) and the spectrum thus observed step by step. Quite large solid angles can be focused in this way, and if the magnet is rotatable, the angular distribution of each component of the spectrum may be determined. The optical analogue to this is a prism spectrometer.

Or the magnet may (*b*), at a given field, bring particles of different energies to different focal points, along a photographic plate, thereby determining the entire spectrum in one exposure, as indicated in Fig. 10. For such purposes, only a much smaller solid angle may be accepted. The optical analogue to this is the spectrograph. Fig. 11 shows a multichannel nuclear spectrograph. The type (*b*) is of most use in determining the spectrum and angular distributions of emitted charged particles, from which such nuclear properties as spin and parities may be determined.

Broad Range and Multichannel Spectrographs

There are also two magnets of the broad range magnetic spectrograph type. One, used in conjunction with the 6 MeV machine, will observe only one angle at a time, but is so mounted, that the angle of observation may be varied. A homogeneous circular magnetic field of $\sim$ 50 cm radius is used to focus charged particles differing in energy by as much as 2·5 to 1, on to a 30 in long nuclear emulsion plate. The practical energy resolution of the instrument is limited to between 1,000 and 1,500 by the size and thickness of the target, and the spread in energy of the ion beam from the accelerator. The magnet weighs about 8 tons and is energised by a 24 V 300 A supply, regulated to maintain the field steady to within 1 part in 10^5.

A second magnet (Fig. 11), still under construction, will be used in conjunction with the 12 MeV tandem electrostatic generator. The magnet weighs 13 tons, and is in the form of a large ring into which are cut 24 $\frac{3}{8}$-in air-gaps at approximately $7\frac{1}{2}^\circ$ intervals. Each gap constitutes a magnetic spectrograph of similar specification to that of the broad range spectrograph described above. The entire magnet, energising current and plateholder assembly, are contained in a vacuum vessel $8\frac{1}{2}$ ft in diameter and 9 ft high. The field, of 12,000 gauss, stabilised to 1 part in 10^5, is maintained by a 320 turn coil (1,000 A, 60 V). The vacuum of 10^{-4} to 10^{-5} mm Hg is maintained in the vessel by a large oil diffusion pump, 24 in in diameter. The 24 nuclear plates are 40 in by 1 in wide, and cover simultaneously an angular range of 5° to 175°. Thus a spectrum and the angular distribution of each component of the spectrum, is determined in one exposure.

Neutron Emission Discrepancy Removed

A large liquid scintillation counter is in use at AWRE as an efficient neutron detector and is at present set up to measure the number, $\bar{\nu}$, of neutrons emitted in the fission of heavy isotopes. An important result recently obtained with this apparatus is that the number of neutrons emitted in the slow neutron fission of uranium 235 is about $6\frac{1}{2}$ per cent lower than the currently accepted world best value. This result removes some well known discrepancies and is equally important to both reactor and weapon physicists.

Harwell and Liverpool Tandem Accelerators

A 12 MeV tandem electrostatic generator is also to be installed at Harwell and possibly another at the University of Liverpool in the Nuclear Physics Research Laboratory. The department hopes to obtain the machine under a DSIR grant.

Chalk River Tandem Accelerator

A tandem accelerator, designed and built by High Voltage Engineering Corporation, Burlington, Massachusetts, has recently started operation at the Chalk River establishment of Atomic Energy of Canada Limited. The $1,000,000 tandem accelerator, which will be in use 16 hours a day, consists of two Van de Graaff accelerators placed end to end, horizontally, in a 23 ton steel pressure tank, which is 34 ft long and 8 ft in diameter. The tank contains nitrogen at a pressure of 225 lb per sq. in to insulate the accelerator, preventing escape of the electrical charge built up by the machine. A beam of particles (for example, protons) is di.ected into the first of the two Van de Graaff units where it is given an energy of 5 million volts. The beam then travels into the second Van de Graaff unit where the particles are further accelerated, reaching a total energy of 10 million volts. This beam of particles is then directed against target materials (such as magnesium or lead). The accelerator is mounted on rails in an L-shaped building 150 ft long and 60 ft wide. A high mound of earth on one side of the building and thick concrete walls on the other side act as shielding against high energy radiations. A separate building houses the control room. A closed-circuit television system permits workers to observe events in the accelerator room while the machine is in operation.

Fig. 13 View of the CERN site at Meyrin, showing the ring of the 25 GeV proton synchrotron.

Companies Contributing

The Metropolitan-Vickers Electrical Company Limited, a member firm of AEI, took part in the design and construction of the AWRE tandem accelerator; and John Thompson Limited, who are associated with AEI in nuclear work, built the pressure vessel. Metropolitan-Vickers have also assisted in the construction of the linear injector for the CERN proton synchrotron, and in the manufacture of components including the magnet coils for the 7 GeV proton synchrotron Nimrod now building for the National Institute for Research in Nuclear Science. They have also built 25 MeV electron and 50 MeV proton linear accelerators for Harwell and numerous machines for university and medical work. They are at present engaged in building the linear

injector for the 6 GeV electron synchrotron under construction for Deutsches Electronen Synchrotron (Desy) of Hamburg.

Nimrod Named

The 7 GeV proton synchrotron under construction for the Rutherford High Energy Laboratory of the National Institute for Research in Nuclear Science has been given the name Nimrod. The machine, which is about half way to completion, is shown in Fig. 12. Some 155 ft in diameter, it will comprise a ring of 336 magnets each weighing 20 tons. Protons will be accelerated by radiofrequency pulses and will make 1,125,000 circuits in 0·7 seconds before reaching 7 GeV. The machine will employ strong focusing but not, after all, the spiral ridge principle. Costing £7 million, Nimrod should be ready in about two years.

Big Accelerators throughout the World

The largest proton accelerator now in operation in the United States is the 6 GeV Bevatron at the Lawrence Radiation Laboratory, operated for the Commission by the University of California. The world's largest operating accelerator is a 10 GeV machine in Russia. Two 25 to 30 GeV proton machines are under construction, one at Brookhaven National Laboratory, Upton, Long Island, New York, and the other at Geneva, Switzerland, by the European Organisation for Nuclear Research (CERN). A view of the CERN site at Mayrin appears in Fig. 13. All of these machines are of the circular type.

American 45 GeV Linear Accelerator

As stated recently by President Eisenhower, Congressional authorisation for construction of a two-mile-long linear accelerator at Stanford University will be sought by the US Atomic Energy Commission during the current session of Congress. The proposed 15 GeV accelerator should eventually be capable of operating at 45 GeV. The Stanford project would be established as a national facility for research, to be used by scientists from other institutions as well as those at Stanford. A procedure would be established for screening proposed experiments and scheduling the use of the huge machine. The accelerator is planned for construction near the Stanford campus. The apparatus would be enclosed in two parallel tunnels, each nearly two miles long and covered by 35 ft of earth. On the basis of preliminary estimates, the project would cost about $100 million for construction, $18 million for research and development, and approximately $15 million a year to operate after completion. The Commission would finance the project, and Stanford would operate the machine. Construction would take six years.

Spiral Ridge Cyclotron at Dubna

A cyclotron employing the spiral ridge principle is reported to have been operating at the Joint Nuclear Research Institute near Moscow since January. Designed to test the ridge effect, the machine was designed by V. P. Zhelepov and colleagues. As the particles move outward on a spiral path their mass increases with speed by relativity effect, and it becomes necessary to augment the magnetic field to keep the particles on track, or focused. Ridges are introduced into the magnet pole faces to achieve this result, and, though simple radial ridges give the required strong-weak field alternation, spiral ridges are preferred since they interfere less with the working space between the magnet poles; their focusing effect is also stronger. Intense beams produced in this way give higher probability of projectile and target nucleus interactions.

Birmingham Cyclotron Ridge Conversion

The 37-in cyclotron at Birmingham University is being converted to give intenser particle beams using the ridge principle.

East German Betatron

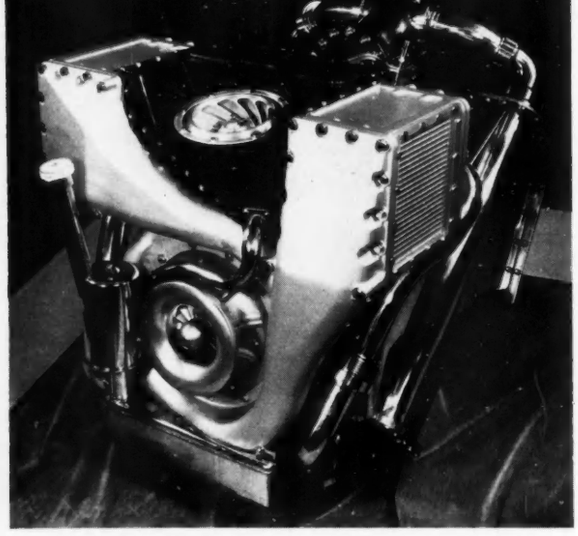
It is reported that a betatron has recently come into operation at East Germany's nuclear research centre near Dresden.

Automobile Engineering

FORD 704 GAS TURBINE MODEL

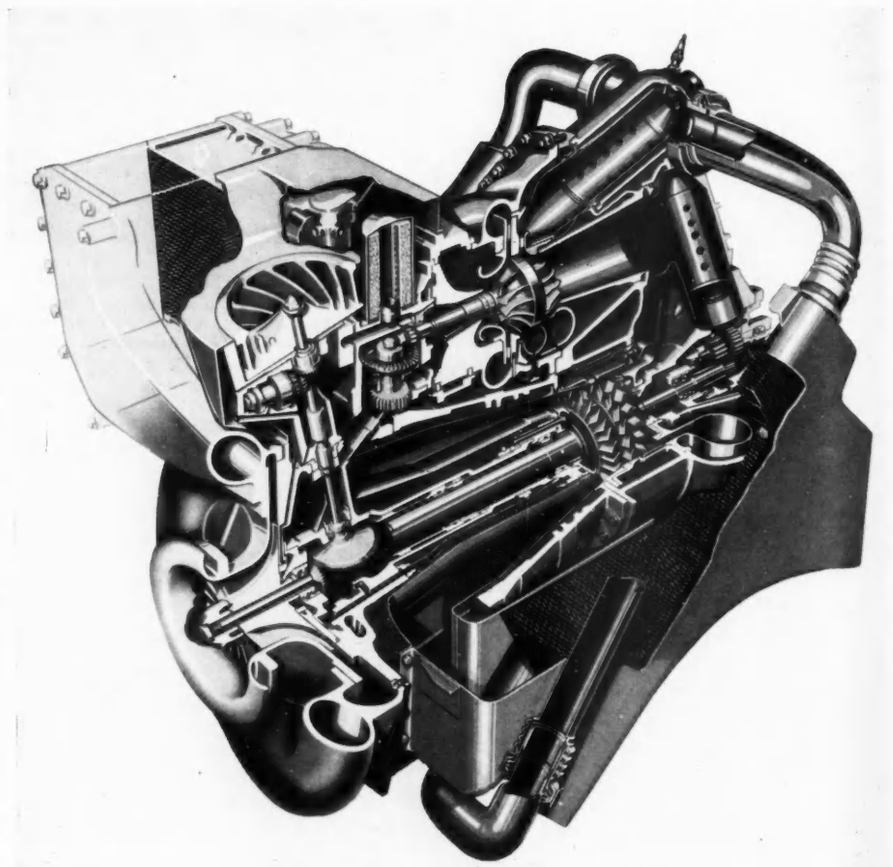
Further Tests to be Made this Month

The Ford 704 gas turbine engine, preliminary details of which were given in ENGINEERING on 22 May, is reported to be scheduled for testing as a complete unit some time this month. Test results and further technical details are expected to follow some months afterwards. In the meantime the Ford Motor Company, Michigan, USA, have released the accompanying cutaway drawing and photograph of the engine. They also report that component testing so far has, in all cases, yielded results that are within 3 per cent of design.



The 704, which weighs only 650 lb, is said to develop 300 h.p., using two stages of compression. Each stage effects a four to one air compression, the low speed compressor turning at 46,500 r.p.m. and the high speed at 91,500 r.p.m. Its "package" size is 38 in long, 29 wide and 28 high.

The cutaway drawing shows the low pressure compressor and turbine drive assembly, lower centre; intercooler fan, upper left foreground; intercooler, extreme upper left; high pressure compressor, turbine and accessory drive, upper centre; primary and secondary combustion chambers, upper right; exhaust heat exchanger, lower right; and power output turbine, right centre.



X-RAY IMAGE AMPLIFIER

High Definition at Low Dosage

The recent development of an X-ray image amplifier to assist radiologists in carrying out fluoroscopic examinations, has resulted in an apparatus which will be of considerable benefit to medical research and diagnosis. In addition to its present physiological applications, it is thought that the basic features of this system may be further developed to be of use in industry, particularly in the field of metal radiography.

The apparatus, known as the Marconi Large Screen Image Amplifier, enables fluoroscopic images to be viewed on a 12 in television monitor. The size of the screen and the high quality of the image will be of particular assistance in medical diagnosis. In addition, a cine-camera attachment will, for the first time, enable a continuous record of fluoroscopic images to be made without harm to the patient.

One of the most valuable features of the image amplifier is that it enables examinations to be made with a lower than usual X-ray dosage. During recent tests on the equipment, the unusually low dose rate of 2 milliroentgens per second has been successfully used to view a thorax while maintaining an image of sufficient clarity for accurate diagnosis. The reproduction of the fluoroscopic image on a television screen permits the monitor to be placed in the best position for comfortable viewing by one or more radiologists. It also is possible to have several additional monitors at points remote from the examination room.

(Right) Marconi Image Amplifier combines X-ray and television techniques.

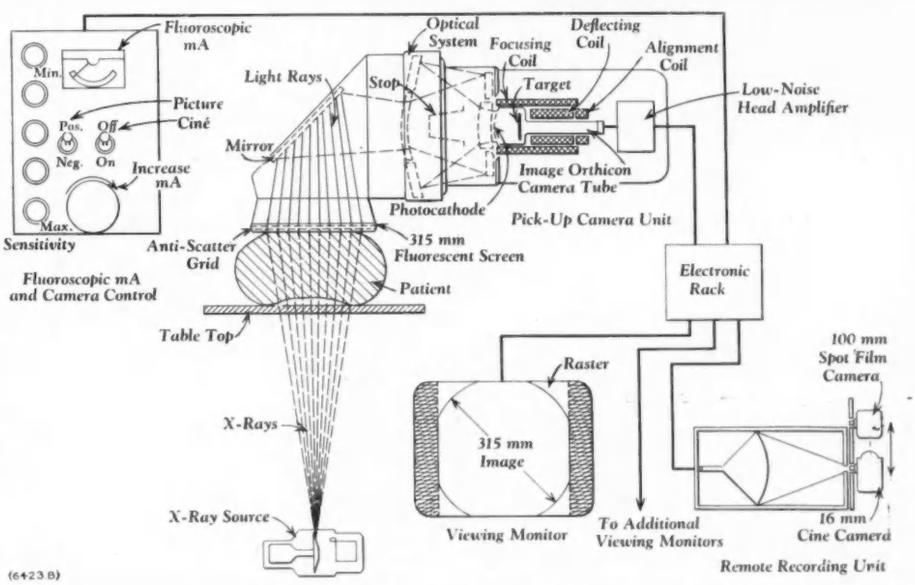
CONTROLS

The controls of this equipment have been ergonomically designed for operation by radiologists. Five push buttons, which are physically large and therefore easily operated when wearing lead-rubber gloves, control the sensitivity of the image amplifier without involving any alteration to the X-ray output. They provide the operator with a means of selecting the best image for any given X-ray technique and their preset positions can be chosen by the radiologist when the equipment is installed. A continuously variable control, and a milliameter giving a direct reading of X-ray tube current, are also provided.

One of two switches on the remote control unit operates the serial film or cine radiographic recording unit. This permits the operator to make a permanent record of any part of an examination without any interruption to the image appearing on the monitor screen. The second switch governs the polarity of the image. This facility is unique in this application and enables the radiologist to reproduce the image in positive or negative form at will.

Although not yet fully developed, an additional unit is to be produced by the same company, Marconi Instruments Limited, St. Albans, Hertfordshire, which will enable a further reduction in the patient dose. This unit will provide an alternative to the conventional fluoroscopic techniques in which the patient must be irradiated during the whole period required to assimilate the information contained in the image. By employing this unit it will only be necessary to irradiate the patient for the time needed to form the image, which is then held on the viewing monitor until the next image is required. By using a slow repetition rate, a stroboscopic view of moving body parts could also be obtained.

(Below) Circuit layout of system.



CAMERA UNIT AND MONITOR

This is attached to the screen tower so that the centre of the X-ray tube focus is maintained in line with the centre of the fluorescent screen at all times.

After passing through the patient, the X-ray beam impinges on a high definition fluorescent screen contained in the base of the camera unit (see diagram). The resultant image is reflected, via a plane mirror, to a lens system and thence to the photocathode of a special type of image orthicon camera tube. Following electronic amplification the image is then reproduced on the screen of a television monitor. In addition to the screen, lens system and image orthicon camera tube, this unit contains a low noise head amplifier and a scanning unit.

The final image is displayed on a rectangular cathode ray tube with a 17 in diameter screen. The actual image occupies the central area of the screen being 11 in square with rounded corners of 12 in diameter. This size is identical with that of the original fluorescent screen contained in the camera unit so that, although the image has been increased in brilliance, the physical size remains unaltered. To give the radiologist some additional control over the quality of the final image, the monitor is fitted with a brightness and contrast control, conveniently placed on one side of the case.

A 1,000 line, triple interlace system is adopted in this equipment to provide a high definition image. This ensures no reduction in picture quality from that of the intrinsically high definition fluorescent screen used in this equipment.

SYSTEM ASSEMBLY

Both the camera unit and the viewing monitor are ceiling suspended on overhead rails, the camera unit being clamped in position immediately above the table top. The overhead carriage, from which the camera unit is suspended on telescopic arms, is mounted on rails which are normally attached to the ceiling. The carriage runs freely along the entire length of the rails and will also travel in a transverse direction to cover the entire area of the table.

NEW INDUSTRIAL TELEVISION SYSTEM

Incorporating Broadcast Standards

Most industrial television equipment to date has been designed to a specification somewhat lower than that of broadcast equipment. However, experience over the past few years has shown that many industrial applications of closed circuit television demand specifications as good as, or even better than, those used by the BBC.

Television camera head.

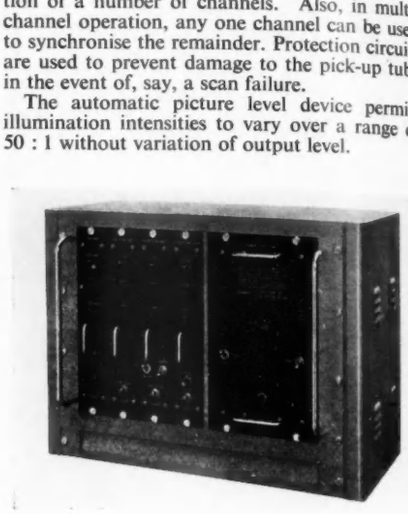
The Epsylon industrial television system, which has recently been developed at the Feltham laboratories of Epsylon Industries Limited, has a clarity of definition equal to that obtained by the leading broadcast companies in this country, and incorporates reliability and operational convenience as two major features. This system has been designed for operation in severe industrial environments, with a minimum number of controls and adjustments.

The camera is fully automatic and all d.c. supplies are stabilised to eliminate effects of supply variation. The incorporation of a device which automatically controls the signal level whenever the light level changes, and a unit for remote control of electrical functions, has made it possible to eliminate camera cable runs by stowing the control unit near the camera head.

The input and output connections of the camera control unit are situated at the rear and consist of camera cable, mains, video out, external synchronising input (bridged or terminated) and remote operation. An additional coaxial cable within the main camera cable and the use of a bridged video output connection enable a small 8 in picture monitor to be used as a viewfinder for studio operation.

Provision is made for the insertion of an external synchronising waveform to produce 2 : 1 interlaced scans and synchronising operation of a number of channels. Also, in multi-channel operation, any one channel can be used to synchronise the remainder. Protection circuits are used to prevent damage to the pick-up tube in the event of, say, a scan failure.

The automatic picture level device permits illumination intensities to vary over a range of 50 : 1 without variation of output level.



Camera control unit.

TUBE TRAIN TESTS — *Determine Impact of Wheels on Rails*

The vertical impact forces imposed by the wheels of tube trains on the joints of rails have been examined in some tests made by London Transport. The tests were also designed to show the effect of the impact on nose-suspended traction motors with different types of bogie and motor suspension, and to determine the advantages that would derive from providing resilience in the traction motor mountings.

Tests were made on both ballasted and solid track formation, and with full-head and flat-bottom rails. Suitable lengths of new 95 lb B.H. and new 98 lb F.B. rails were laid in a fast road where the track is ballasted, and also a track where the formation is of concrete.

Sections of the new running rails on both sides of selected rail joints were mounted on load measuring baseplates fitted with strain gauges, the signals from which were picked up by a multi-channel recorder at the side of the track. In addition, accelerometers were fitted under traction motor cases on the rolling stock, signals being fed to a cathode-ray oscillograph and camera on the train.

Tests were made with three types of Tube stock having, respectively, rubber axlebox and bogie bolster suspension (1956 " silver " stock), and solid or semi-resilient motor suspension (1938 stock). Tests were made also with three types of Surface stock. Readings were taken as the trains ran over the test lengths of track at speeds up to 50 m.p.h. Communication between personnel on the trains and at the trackside was by radio-telephone. The analysis of the test readings is a lengthy process and the results will not be available for some time. The tests were carried out in conjunction with British Railways' Research Department which is located at Derby.

THE OPHITRON — *A New Microwave Oscillator*

A compact microwave generator, embodying a new focusing principle, has been developed at the research laboratories of the General Electric Company at Wembley, Middlesex.

The valve is an electrostatically focused, backward wave, oscillator which has been named Ophitron—after the Greek *Οφις*, meaning serpent, the word being suggested by the undulating path of the electron stream flowing along the structure.

The most striking advantages of this new oscillator are its small size (6 in long × $\frac{3}{4}$ in diameter) and its low weight (7 oz). In addition, the Ophitron system has been designed for simplicity of both construction and operation. A single stamped-out periodic structure and two flat focusing plates form the propogating path for the r.f. wave and set up the periodic electrostatic field which focuses the electron beam. The system has the fundamental advantage that the crests of the undulating electron beam are brought into the region of maximum r.f. field. This feature gives good coupling between beam and wave and leads to greater bandwidth than is obtained with the equivalent magnetically focused backward wave oscillator.

The present design tunes electronically over at least a 40 per cent band in the 10,000 Mc/s region. A range of such valves is envisaged in the near future, covering most of the important centimetre wavelength bands. It is expected that the noise performance will be better than that of magnetically focused backward wave oscillators, due to the ion drainage from the electron beam in the new focusing method.

This novel device, which is expected to have many applications in military and commercial fields, will be manufactured and sold by the MO Valve Company Limited, Hammersmith, London. It is believed that it will be the first microwave oscillator with electrostatic focusing to be commercially produced.

MEETINGS AND PAPERS

Antiquarian Horological Society

LONDON
" American Clocks, 1780-1840," by D. K. Packard. Science Museum, South Kensington, SW7. Thurs., 18 June, 7 p.m.

Association of Supervising Electrical Engineers

CANTERBURY
Annual General Meeting. East Kent Branch. County Hotel, Canterbury. Tues., 16 June, 7.30 p.m.

LUTON
Discussion on " Contactor Gear Maintenance." Luton Branch. Luton Chamber of Commerce, George Street West, Luton. Wed., 17 June, 8 p.m.

British Institute of Radiology

LONDON
Various short papers. Fri., 19 June, 11.30 a.m. and 2 p.m.

Combustion Engineering Association

LONDON
Brains Trust Meeting on " The Working of the Clean Air Act, Particularly with Regard to Experiences of Prior Approval under Section VI." Southern Region. St. Ermin's Hotel, Caxton Street, SW1. Thurs., 25 June, 10.30 a.m.

Institution of Public Health Engineers

LONDON
Annual General Meeting at 4.45 p.m. " New Headworks and Reservoir, Hanningfield," by W. C. Young and G. Davis, at 6 p.m. Caxton Hall, off Victoria Street, SW1. Fri., 19 June.

Physical Society

LONDON
" Problems in the Modern Lightweight Building: Acoustic Privacy versus Planning Flexibility," by Professor Robert B. Newman. Acoustics Group. Physics Department, Imperial College, South Kensington, SW7. Thurs., 18 June, 5.30 p.m.

Royal Meteorological Society

LONDON
Various short papers. Wed., 17 June, 5 p.m.

Institution of Public Health Engineers, c/o Portman Building Society, Portman Square, London, W1.

Physical Society, 1 Lowther Gardens, South Kensington, London, SW7. (KENsington 0048.)

Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, SW1. (KENsington 0730.)

ROAD CONSTRUCTION IN WESTERN IRAN

The World Bank, with the participation of four private American banks, has made a loan equivalent to £25¾ million to Iran for the construction and improvement of roads included in Iran's Second Seven-Year Development Plan. The road project will affect the most populous and productive part of Iran, that in the west; it is expected to stimulate agricultural output and to facilitate the movement of goods in internal and international trade.

The loan is the largest ever made by the Bank for a road project. It will help to finance the construction or reconstruction of about 1,530 miles of main roads in western and southern Iran, including the Trans-Iranian highway from the Persian Gulf to the Caspian Sea; the improvement of a 270 mile road link that will connect the important Shiraz Province with the Gulf ports of Khorramshahr and Bandar Shapur; and the planning and preliminary engineering of feeder roads in the principal agricultural areas and of main roads to be included in Iran's next road programme. The principal roads are shown in the accompanying map.

Inadequate transport has long been a major handicap to the economic development of Iran—an area as large as Germany, France, Italy and Spain combined. Out of the population of 20 million, 80 per cent are engaged in agriculture on terrain that is mainly arid and mountainous. Not many of Iran's 15,500 miles of roads are built to standards adequate for motor vehicles and most of them are in need of repair. This has reduced the incentive to increased agricultural production. Inadequate road transport has also been an obstacle to the execution of government-sponsored development projects and to the growth of private industry.

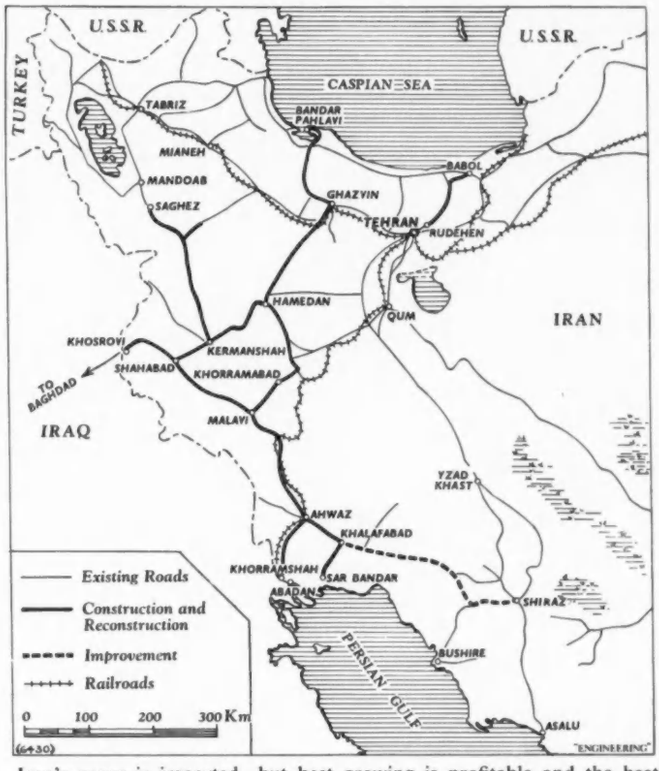
The Plan Organization, Iran's economic development agency, is responsible for the construction or reconstruction work to be undertaken. Consulting engineering firms are designing the roads and will be supervising their construction, and the work will be carried out under unit price contracts let on the basis of competitive bidding. Iran's Ministry of Roads, advised by the US Bureau of Public Roads, is responsible for the improvement of the road linking Shiraz with the Gulf ports, and for the maintenance of all roads in the project. To eliminate one of the principal causes of deterioration of Iranian roads—the overloading of trucks—the Government has initiated a number of measures designed to control the weight of vehicles.

The project is scheduled for completion by mid-1962 at a total cost equivalent to £66 million in Iranian rials and foreign exchange. The new loan of 25¾ million will cover the foreign exchange requirements and a small part of the local currency costs. The remainder will be provided by the Plan Organization from its share of Iran's oil revenues, and from further possible borrowing.

Khorramshahr-Bandar Pahlavi (Trans-Iranian Highway).—The longest road in the current programme is the Trans-Iranian Highway, which runs from the port of Khorramshahr on the Persian Gulf northward to the port of Pahlavi on the Caspian Sea, a distance of more than 745 miles. This road, crossing a number of mountain ranges with passes above 5,000 ft, requires substantial reconstruction as well as relocation. About 70 per cent, or roughly 400,000 tons, of goods handled by the port of Khorramshahr are now carried over this highway.

Hamedan-Kermanshah-Khosrovi.—This road runs 235 miles from Hamedan via Kermanshah to Khosrovi in the west and will be used primarily for the exchange of goods between the Kermanshah area and Teheran. Kermanshah Province produces large quantities of wheat, beans, dried grapes and livestock, mainly for the markets of Teheran and Khorramshahr.

Malavi-Shahabad-Kermanshah-Saghez.—This road will shorten the road distance between the main Gulf ports and Tabriz in the northeast by about 155 miles. One section of it will give access to a wide agricultural valley south of Kermanshah in the Karkheh river basin. Much of



Iran's sugar is imported, but beet growing is profitable and the beet factory in this area is working below capacity. Adequate transport should greatly stimulate production. Another section of this road is important as a more economical means of transporting fuel from Kermanshah to the area around Tabriz.

Rudehen-Amol-Babol.—The area on the Caspian Littoral is Teheran's principal source of perishable vegetable products. At present this area is connected with the capital by several winding roads crossing a mountain range at high altitude. The new road is to be built over a low pass and will shorten the connection by about 62 miles.

Sar Bandar-Khalafabad-Ahwaz.—All traffic (about 400,000 tons a year) through Bandar Shahpur, the Gulf port 10 miles south of Sar Bandar, is transported by rail because of lack of a road connection beyond Sar Bandar. The construction of a road between Sar Bandar and Khalafabad (which is connected with the Trans-Iranian Highway) will permit trucks to reach the port and greatly relieve the pressure on port facilities.

Shiraz-Khalafabad Road Link.—The Shiraz-Khalafabad road being improved by the Ministry of Roads will link the Shiraz region with Iran's main ports on the Persian Gulf. A through connection from Shiraz to Khalafabad and thence to Bandar Shahpur will stimulate exports not only from the Shiraz province but also from the Isfahan Province in the centre of the country.

GOOD PRACTICE IN EARTHWORKS

The British Standard Code of Practice, CP2003: 1959, *Earthworks*, has been prepared by a drafting committee convened by the Institution of Civil Engineers. It deals with earthworks in connection with only general civil engineering; tunnels, dams, dykes, canals, dredging and river training works are excluded.

Advice is given on such matters as soil classification, weather conditions, and the economic aspects of earthwork design. There is full guidance on the design, drainage and construction of cuttings and embankments and of shallow cut-and-fill and compaction earthworks; this is followed by a section on construction methods and the use of plant. A substantial section of the Code is devoted to trenches, pits and shafts, covering such matters as site considerations, methods of excluding water, and the degree of support required in varying ground conditions. Excavation, timbering and back filling are fully dealt with, and so are blasting and excavation in rock. There are also a number of useful tables dealing with such matters as the classification and characteristics of soils and the design of rock slopes; and among the 28 illustrations are shown examples of accepted methods of timbering and of drilling for explosives.

The Code is based on conditions likely to be met in the British Isles, but a few references have been made to conditions overseas where this appeared desirable.

Copies of this Code of Practice, which contains 139 pages, may be obtained from the British Standards Institution, 2 Park Street, London, W1 (25*s*, postage extra to non-subscribers).

FOREST PRODUCTS RESEARCH

The annual report by the director of Forest Products Research for 1958 has been published. The year covered the period during which responsibility for industrial work, together with associated advisory services, was being transferred to the Timber Development Association, who tend to specialise in the development of timber structures.

This transfer of work will leave the FPR Laboratory freer to concentrate on basic research and some emphasis is to be placed on examining properties of home-grown softwoods. Group studies are also in hand on the strength of composite wood assemblies; woodworking, expecially cutting, problems; gluing and glues as applied to adhesives; and wood preservation. The Laboratory is continuing its work on mycology and entomology.

RAILWAY MAINTENANCE SHEDS FOR SOUTHERN REGION

In connection with the electrification of the East Kent coast services of the Southern Region of British Railways, the railway workshops and sidings at Ramsgate and Stewarts Lane, Battersea, have been extended and modernised on behalf of British Railways by Holloway Brothers (London) Limited, who have undertaken the civil engineering work.

There were four main contracts at Stewarts Lane depot. Under one a large steel framed running shed facilities have been provided for maintaining main-line electric locomotives. These include staff accommodation, stores, heating, lighting, gas, hot and cold-water services. The shed has two 25 ton overhead travelling cranes, an Atlas wheel lathe installed below ground level, and two full-length inspection pits. Electric light bulkhead fittings and low-voltage socket outlets for operating electric tools are built into the sides of the pits. New roads, track-laying and a retaining wall are included in this contract.

The existing carriage cleaning shed has been extended and now has 14 sidings, with eight new inspection pits for maintaining 12-car electric trains. There is provision on all sidings for washing down and cleaning out carriages. A new boiler house has two oil-fired boilers, each developing 12,500,000 Btu per hour, to feed a network of high-pressure hot-water mains at 250 lb per sq. in and 360° F. Five calorifier rooms receive adequate heating from these boilers to supply low pressure heating for offices, workshops, and carriages being serviced in the cleaning shed.

Conversion of part of the steam locomotive shed provides for housing, inspecting and carrying out repairs on the new diesel locomotives. Adjacent to this there is a fuelling and servicing siding to supply locomotives with diesel oil and water. A comparatively new idea instituted by British Railways is the construction at Stewarts Lane of a drivers' training school. This is a modern building having three lecture rooms, a mess room and other facilities where drivers are instructed on the working and driving of diesel and electric locomotives.

At Ramsgate, Holloways have erected a multiple unit lifting shed, which is in all constructional respects similar to the locomotive running shed at Stewarts Lane. There is, however, only one 25 ton travelling crane and no wheel-truing lathe.

There have been extensions to the carriage cleaning shed, involving breaking up and relaying about 1,600 sq. yd of floor; lifting and relaying about 300 yd or track inside the shed; and laying down reinforced concrete aprons at each end of the shed, including about 220 yd of track. A lean-to of brickwork alongside the shed houses new offices and staff accommodation of about 2,000 sq. ft floor area and another 1,500 sq. ft of existing offices and accommodation are now fully modernised.

A carriage cleaning stage was formed with precast concrete units about 2 ft 4 in wide and of a total length of 820 ft. Straddling the platform and the tracks on either side are steel gantries carrying lighting and water services at approximately 66 ft intervals, equal to the length of a carriage.

WORLD BANK MISSION GOING TO TANGANYIKA

The World Bank is sending a mission to Tanganyika to make a general survey of the economy and assist in forming a programme of economic development. The mission is going at the joint request of the governments of the United Kingdom and of Tanganyika. Members of the mission include advisers on water and mineral resources, transport and communications, agriculture, as well as industry and trade generally.

Progress on London-Birmingham Motorway

Construction of the 70 mile motorway between London and the Midlands is making good progress towards the completion date of October next. Over 140 of the 180 bridges along the route have been substantially completed in the 15 months since the contracts were let.

On the main stretch of the road north of St. Albans, 5 miles have been finally surfaced and the contractors, John Laing and Son, are continuing asphalt surfacing at a rate of 3½ miles of dual carriageway each week. On the St. Albans bypass, which is an all-concrete road being built by Tarmac Limited, the contract for the first 12 miles is half completed. The Watford "leg" of the bypass is being built by a consortium of three contractors: Fitzpatrick and Sons, Holland & Hannen and Cubitts, and Lehane, Mackenzie and Shane. This work, started last summer, is now about 30 per cent complete. Two-thirds of the earthworks have been carried out and a start made on all the bridges; the decks of some of the bridges have been finished.

Redevelopment of Inland Waterways

First priority is to be given to improvements to the Stratford-on-Avon canal (southern section), the Pocklington canal, and the Staffordshire and Worcestershire canal, by the Inland Waterways Redevelopment Committee recently set up to promote schemes for the treatment of canals which cannot be maintained for commercial transport. In Scotland prior attention will be given to the Monkland canal.

Concrete Dome for Australian Academy of Science

The new premises for the Australian Academy of Science, just opened, is a concrete dome which has been given a skin of copper sheets. The floor area is 24,175 sq. ft and, at the crown, is 45 ft high. At the periphery it is supported by semi-circular arches with their springings sited in a moat. Entrance to the hall is by a bridge paved with glass and gold mosaic tiles crossing the moat.

An air-conditioned circular conference room has seating for over 150 and the 30 rooms include reception suites, committee rooms, administrative offices and an exhibition gallery. Interior lighting comes from circular vents let into the concrete shell. These admit natural light but are also fitted with supplementary tube lighting.

Stamford Bypass on the Great North Road

A contract for improving the Great North Road by constructing a bypass around Stamford in the East Midlands has been let to A. Monk and Company Limited of Stamford. The cost of the work will be about £1,450,000. Supervision of the work will be in the hands of the consulting engineers, Stirling, Maynard and Partners of Peterborough, who prepared the plans for the new bypass. In all, eight bridges are to be built, all in reinforced concrete.

Wave Formation in Shallow Water

A very full analytical treatment of wave formation in shallow water, and an account of a related experimental study, is given in the March issue (vol. 18, No. 3) of the *Memoirs* of the Faculty of Engineering of Kyushu University, Japan. The report is the work of Daikaku Manabe, assistant professor of aeronautical engineering.

The principal findings are that the properties of waves generated in a shallow-bottomed water tank are accountable in general to the linear theory of wave motion; for shallow water waves, the action of surface tension cannot be omitted; and waves must be compared at the same Mach number and depth.

Snowy Mountains Power Station Commissioned

The large T1 underground power station on the Snowy Mountains hydroelectric power project in South Australia began operation on 4 May. The first generator, with a capacity of 80 MW, was commissioned. A few days later a second similar set came onto power. The current is being fed into the New South Wales electricity system and, subsequently, power will be exported to Victoria.

More Work by Contractors

Constructional work to the value of £448 million was carried out by contractors in the first quarter of 1959, according to provisional figures issued by the Ministry of Works. This represents an increase of £14 million (3 per cent) over last year's figure—an improvement that may be attributable to the better weather in the early part of 1959.

New work for public authorities, other than housing, showed no change from the last quarter of 1958 and there is no sign of any upward movement in the amount of work being done on industrial buildings. New housing by both local authorities and private enterprise is increasing. The total labour force (operatives) is up by 0·7 per cent to 1,035,000.

Road Building in Scotland

The latest chart in the "See How They Go" series issued by the British Road Federation shows road schemes costing over £100,000 started in Scotland during the year ending 31 March, 1959. By far the largest project mentioned is the construction of the Forth road bridge and the approach roads, due for completion by December, 1964, at a cost of £16 million. Four other trunk road schemes and three other classified road projects are mentioned, most of them to be completed about the end of 1960. Copies of the chart are available from the Federation, 26 Manchester Square, London, W1.

Trans-Canadian Highway Progress

It is expected that the British Columbia section of the Trans-Canada highway will be completed next year. The highway will provide an all-weather route through the Rockies. The territory is very hard going, so much so that construction costs are averaging as much as $200,000 a mile, compared with $95,000 in Ontario; the difference is said to be wholly due to the differences in terrain.

Woodfilled Intermediate Span Joists

A new catalogue of woodfilled joists has been issued by Metal Sections Limited, of Oldbury, Birmingham, a Tube Investments subsidiary. New are the intermediate span joists, in the form of open-web girders, suitable for spans from 20 to 60 ft. The depth of the joists varies in 2 in increments from 14 in to 28 in. The boom section incorporates a standard sized timber nailing fillet. All steel is protected by chemical pretreatment and high-temperature stoving; the bracing tubes are of Cor-ten cold roll-formed tubes, bent and arc welded to form a continuous system. Full design details and loading tables are given in the catalogue.

On the Shelf

By Frank H. Smith

By a happy coincidence, the Plain Words of 22 May, in which Capricorn (the tropic topic) advocated the extension of Do It Yourself to Every Man His Own Typist, flopped on my desk at the same time as the *SAE Journal* where the editorial was entitled "Is Dictation Writing?" Here, the writer points out how business letters suffer for being dictated. "It just isn't natural to speak in the crisp, lean sentences which good business writing needs." I am afraid I do not agree. A business letter lacks personality because the writer insists on suppressing his individuality for the sake of businessese. One occasionally receives a letter from a man who writes as you would expect him to talk. That letter is a pleasure to receive and it provokes a quick reply in the hope of a prolonged correspondence. Most "official" letters have as much character as italic writing or an electric typewriter.

An unusual but quite interesting bookseller's list to get hold of is *Scientia Scandinavica* (a review of recent research work published in Denmark, Norway and Sweden). Get it from Fritze's Kungl, Hovbokhandel, Stockholm, Sweden. Hopping south, slightly, we have North-Holland Publishing Co. (N.Z. Voorburgwal 68-70, Amsterdam-C) offering what they imply to be the first text-book on asymptotics—*Asymptotic Methods in Analysis*, by N. G. de Bruijn at 40*s*. From the same publisher comes *Turning Points in Physics*—seven lectures given at Oxford in non-technical language and intelligible, therefore, to the layman. For £1.

P. Noordhoff Limited, Groningen, The Netherlands, advertise a couple of books translated from the Russian on differential geometry and methods of higher analysis. I do not know if these have a different attitude from books we already have in English but if they have not I feel that this is carrying translation too far. The next things we shall have is a Russian book on the Monte Carlo method but called Russian Roulette.

We (and my use of the editorial "we" means that it is something a bit old) have just seen a copy of *Industrial Screen*, a journal now in its third volume (46 Chancery Lane, London, WC2). This particular number (March/April) has an article of particular interest to documentalists in "Document Copying with the Miniature Camera" by a gentleman from Zeiss Ikon.

However green your fingers may be, a good gardening book is always helpful and one of the simplest and most readable that I have ever come across costs but 1*s* 6*d*. It is Dr. D. G. Hessayson's *Be Your Own Gardening Expert*, published by Pan Britannica Industries of Waltham Abbey. It is the sort of book that you can keep by your bedside and still remember the hints you've read in the morning and there is included a square inch of chemically treated paper which tells you if you have a lime-deficiency in your soil. I think you will find your seedsman stocks the book—mine does anyway. My excuse for mentioning it is that it is a most interesting sample of the presentation of technical information.

A paragraph headed "Science library to go to new Siberian university" in the *Soviet Weekly* shook me slightly but it was reassuring to read on and see that this referred to the State Scientific and Technical Library, which is to be housed at the new Novosibirsk State University. The moving of several million volumes should keep somebody busy. Serf them right.

A press handout from Bakelite (usual blue banner—who started this idea?) entitled "Plastics in the Aircraft Industry," has the subheading "Bakelite Limited at the Plastics Exhibition," which I think is a pretty bad show. This is just the sort of place where you want tons of the stuff.

THROMBOSIS IN THE CITY

Parking. By GEOFFREY BAKER and BRUNO FUNARO. *Reinhold Publishing Corporation, 430 Park Avenue, New York 22, NY, USA* and *Chapman and Hall Limited, 37 Essex Street, London, WC2.* (76*s*)

In the present accelerating quest for higher living standards, the motor car has unquestionably become part of the family's living equipment, passing from a luxury to a necessity after the fashion of the vacuum cleaner and the television set. It is also true that the majority of the population contributes to the commercial and industrial life of the established urban centres, which in many instances still bear the firm mark of their mediaeval origin. The road patterns adequate for horse drawn vehicles are now burdened by the most chaotic and intense mixed usage of cars, trucks and buses, which in some inefficient manner serve an ever increasing density of buildings. As one of the problems of city planning, car parking must be as hard to solve as any other.

Information on the difficult and growing parking problem is indeed very welcome, particularly when the source embraces recent studies and observations on the North America environment, for in the United States the paralytic effect is more advanced, and is therefore demanding more urgent attention than in our own country. Whereas one could conceivably have expected the American cities to develop without all the disastrous results of the Industrial Revolution in the British Isles, we, in this country, have been painfully slow in realising that by holding a mirror to the American scene the consequences of mass-produced cars could have been better anticipated.

The parking problem, especially, is not one which can be isolated from the complexity of a city plan. Closely associated with the system of communications, the use and value of land and the almost forgotten considerations of human physical limitations, parking, with its very rigid space requirements, is usually at a premium where space is most expensive and in many other ways, most desirable. In the most simple terms the situation may be summarised: where people wish to go, there also should be provision for their cars, in a similar relation to overcoats and cloakrooms. As the facilities for congregations of people have tended to become denser and more congested, this development has not to the same extent been accompanied by accommodation for private transport. It is evident from certain parking standards illustrated in this book that without the most courageous and enlightened pieces of city surgery, there cannot be any satisfactory solution to parking.

In the new suburban areas there may be time to enforce off-street car spaces by way of zoning ordinances, but unfortunately, it is not here that the problem is at its most critical level. The authors of this book have quite rightly concentrated their attention on the city centre and have run through what seems to be the current methods of alleviating the sorest spots. They do this after examining the possibilities of the increased use of public transport, which to them does not appear likely to succeed. It should be made clear that the standard of public transport in the United States is infinitely lower than in this country, but all the same, here too the trend away from such transport is quite unmistakable. Whether this situation should be allowed to continue is a very debatable point, and, as public transport could help to solve the parking problem, it deserves every consideration.

Once admitting cars to the central area, then the solutions in this volume are amply described by photographs, diagrams, plans and sections. Due to the scarcity of land in city centres, parking is achieved by multi storied structures, some subterranean, but the majority above ground. Curb parking is not recommended. Many of the buildings perform their function and without recourse to superfluities, have been endowed with quality of considerable architectural merit. Often their ramped systems are at the same time ingenious and dramatic. For solutions where land is less precious, and conventional open-air parks are the most economical, it is the very scale which is most depressing.

Normal American standards allow 2½ to 3 times the building area for the car park in the case of shopping centres, and the result is the now familiar picture of an isolated block of building surrounded by a sea of cars. Although the standards may be correct, this answer is far from satisfactory visually. One is led to the conclusion that the economic aspect alone should not be the determining factor which contributes to such a prominent and negative element in the suburban scene.

A very short chapter of this book deals with parking in the landscape, and it is quite evident that the authors are still baffled by the problem, which, there is no denying, is exceedingly difficult.

The book, containing several clearly drawn tables to simplify the design of parking layouts but no bibliography, makes an assessment of the existing car park problems and solutions in the United States. It does not employ an imaginative approach, rather that of an easily read survey, but sheds a most useful light on a topic to the distinct gain of the planner and traffic engineer.

J. S. BONNINGTON

THE SHAPE OF USEFULNESS

The Functional Tradition in Early Industrial Buildings. By J. M. RICHARDS. With photographs by ERIC DE MARÉ. *The Architectural Press, 9-16 Queen Anne's Gate, London, SW1* (36*s*)

All those who have thrilled to the power and mystery of dockyard buildings or felt some dramatic quality in the alleyways among our industrial warehouses will immediately understand the thesis of this book. But even to the "architecturally minded traveller" at whom the blurb aims, Function and Tradition might seem meaningless words, deadened by repetition.

Function was the catchword of the early Modern Movement and although it has at times been treated as a dirty word or meaning something rather less than utilitarian, it remains the "basis on which the architectural philosophy of our time is founded." J. M. Richards (working from his original material published in the *Architectural Review*) sets out to show that functionalism is nothing revolutionary and not confined to the modern movement. A general foreword is followed by chapters on buildings which were not regarded as architecture when they were built in the later 18th and early 19th centuries. There are short notes to each chapter but the book is really a picture book with good and sometimes beautiful photographs of warehouses, dock building, textile factories, water and windmills, breweries, maltings and oast houses, sheds, aqueducts and bridges. The reader is then left to discover for himself what gives these buildings their timeless quality.

They are simple buildings with well defined uses, there are no overworked details, nor was it necessary to detail every corner of the structure because more could be left to the builder than can today. Consequently these buildings do not show the self-consciousness and preoccupation with detail which bedevils many modern buildings. Also "their utilitarian purpose was

not thought to require the artistic treatment that 19th century architects were accustomed to apply to other buildings with the result that the direct relationship of form to function was left unencumbered by irrelevant styling." Many of these buildings, too, need little or no fenestration. The resulting preponderance of bare brickwork or timber boarding empowers these buildings with elements of drama and fantasy which appear strange and attractive to modern ages dulled by curtain walling.

The directness of the engineers' and local builders' response to the challenge of function and materials is clearly demonstrated. An additional chapter on aqueducts and bridges, more engineering structures than buildings, shows that Nervi and Buckmaster Fuller are only implementing a tradition where engineering becomes architecture. The magnificence of the achievements of such men as Telford and Brunel strike one afresh, and make one realise that schemes like High Paddington, commanding all our modern resources, have their courageous antecedents.

This book, then, discovers the folk art of architecture, full or robust vitality and confidence, which is likely to inspire the aforesaid traveller with a new approach to and search for this type of building. It may serve to emphasise a merit often overlooked in these days of official designations when any building not listed as an Ancient Monument or of historic interest may be considered worthless. This book clearly shows that there can be architectural merit in the more anonymous forms of architecture, and possibly conveys more than minor implications relevant to current architecture. Although one detects a photographer's preoccupation with textural effects, a preoccupation which stems from treating the photographs rather than the subject matter as the end product, although a horizontal format would have suited the photographs better (I hate having to twist a book around to see the pictures) and although one could wish for more photographs for 36*s* this could be a valuable aid to the extramural activities of both engineer and layman.

DAVID ROCK

HYPER SHELLS

The Philips Pavilion at the 1958 Brussels World Fair. Reprint from *Philips Technical Review*, Vol. 20, No. 1. *Cleaver-Hume Press Limited, 31 Wright's Lane, Kensington, W8* (5*s*)

The reprint comprises a collection of detailed and well illustrated articles describing the development of this " extraordinary conception and advanced design " known as a shell structure. As might be expected, this paper-backed reprint from *Philips Technical Review* states quite clearly the technical complexities of designing a hyper shell, which is a thin walled structure having the form of hyperbolic paraboloids. The main advantages of a warped plane of this kind are said to be: (1) though doubly curved it can be made of straight members; (2) all stresses are equal (no bending moments); (3) stresses are calculable; and (4) it is very rigid. The necessity for close cooperation between the architect, engineer and contractor at all stages of design is evident, and although these reports were first published by the client and do not attempt any real criticism of the pavilion, they give due credit to Philips for taking advantage of this opportunity to experiment with structure, light and sound.

From the conception of Le Corbusier to house an " Electronic Poem," Y. Xenakis, his collaborator, shows how he evolved with sketches, models and diagrams, the final hyper shell form, and Professor Vreedenburgh explains, with elaborate formulae and diagrams, the theory of the structural design, published we are assured for the first time, but as the introduction kindly warns us " many readers will have difficulty in following the details of his article." Further articles report the results of constructing and testing a series of models of the design and the contractors' approach to the erection of the actual building. All this with the description of the " spectacle of light and sound " to be performed inside the pavilion lasting only eight minutes. If the public who looked and listened to this spectacle were shocked, excited or just baffled, and even if the siting was bad and the whole did look like a collapsed tent, the completed pavilion was a very interesting architectural experiment.

The book, with a neat summary at the end telling readers what they have just read, reports quite thoroughly the findings of all the experiments related to this particular building at all stages of its development, and certainly reveals the wider possibilities of the hyper shell as a structural form.

ROBERT M. SMART

CONCENTRATED LIVING SPACE

Modern Flats. By F. R. S. YORKE and FREDERICK GIBBERD. *Architectural Press, 9-13 Queen Anne's Gate, London, SW1.* (63*s*)

Although the authors say that the trend today is for community and neighbourhood schemes rather than individual blocks of flats, it is disappointing to see that no real " grand idea " has revealed itself—except, of course, for Le Corbusier. While the architecture is good in many cases and the housing standards high, the over-riding idea is still a block of flats or several blocks of flats, grouped together on a defined site. The scale of the idea is not big enough. For example, the motor car, becoming inevitably a member of the family, is not taken care of in many of these communities and is destined to become an orphan. This can readily be seen in the American examples.

Now that tall flats are becoming accepted and architects and engineers have a knowledge of the vocabulary, a realistic approach must be made to the integrated community. With some " big thinking " British designers could easily lead the way. Indeed, at the moment it is encouraging to see that the British section in this book is so large, although it is to be hoped that in future editions (and if this work is to have true value it must be revised regularly), it will have more careful selection. Certainly in the next issue must come the London County Council's Roehampton Estate and Stirling and Gowan's Ham Common flats.

The most that can be said of a picture book of flats is that it gathers together in easily accessible form a selection of the best examples of flat buildings from all parts of the world. Subscribers to a good architectural periodical will recognise in this book most of the examples but it is useful to compare, say, the Lake Shore Apartments, Chicago, and the Unitéd'Habitation, Marseilles, merely by flicking over a few pages.

Since the authors have not set out to prepare a critical study or give a full structural and detailed analysis, it is unfair to criticise them on this score. Some useful background information is given, however, under headings of Type, Access, Number of Flats, Construction, and so on, but it is a pity that more cost information has not been available, if only in the British section.

This completely new work is a worthy successor to the authors' earlier book (*The Modern Flat*—1937) and will find a well earned place on the library shelves of students, and those involved in the design of flats in modern terms.

CHARLES ROBERTSON

The Reviewers

Mr. J. S. Bonnington has worked for the last three years in the office of Basil Spence and Partners on the design of university buildings and Coventry Cathedral. He studied architecture and planning at the University of Durham and was an R.I.B.A. prizeman in 1949 and 1951. After qualifying, he worked in the United States on city plans and urban redevelopment projects. In 1954 he was commissioned in the Royal Engineers. Mr. Bonnington is a B.Arch. (Hons.), a Dip.T.P. (Dist.), and A.R.I.B.A., and an A.M.T.P.I.

Mr. David Rock is a practising architect, and after serving with Basil Spence and Partners has recently become responsible for the London office of Grenfell Baines and Hargreaves. Born in Sunderland in 1929, he was educated at Bede Grammar School and at the University of Durham, where he obtained a first class honours degree in architecture in 1952. He became an Associate of the Royal Institute of British Architects in 1953, won the Soane Medallion in 1954, and was a Rome Finalist in 1957. Apart from two years with the Royal Engineers, spent mainly in Germany, he has been with Basil Spence since 1952. A recent commission completed by Mr. Rock was the newly opened Bumpus Bookshop in Regent Street.

Mr. Robert M. Smart, A.R.I.B.A., is a professional architect working with Basil Spence and Partners.

Mr. Charles Robertson, who obtained his Diploma in Architecture at Dundee, is senior assistant with Basil Spence and Partners, and is the assistant in charge of Mr. Spence's Gorbals redevelopment project in Glasgow. The scheme comprises 20-storey maisonettes plus a shopping and commercial centre. Mr. Robertson has also worked on university buildings, schools, a cinema, and various private houses for several Scottish architects and one English public authority since 1952. He was in the Royal Artillery from 1946 to 1948, and is an A.R.I.B.A. and an A.R.I.A.S.

NEW BOOKS

Conversion Factors and Tables. Part I: Basis of Tables. Conversion Factors. BS350; Part 1: 1959. *British Standards Institution, 2 Park Street, London, W1.* (15*s*)

Subsonic Drag and Pitching Moment Characteristics of Slender Cambered Bodies. By K. D. HARRIS. CoA Report No. 118. *The College of Aeronautics, Cranfield.*

Some Values of the Reduction Factor for Plastic Buckling of Plates in Shear. By B. EMSLIE. CoA Note No. 90. *The College of Aeronautics, Cranfield.*

Hütte: Taschenbuch für Betriebsingenieure (Betriebshütte). Vol. II: Betrieb. Fifth Edition. *Wilhelm Ernst and Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany.* (66 *DM*)

A reference book (for industrial engineers) so well known needs only to be announced. Its index alone could serve as an example of how such things can be done.

METHANE FROM COALFIELDS

1,000 Million Therms Discharged each Year

At the end of 1950 six collieries were draining firedamp and one was using the gas produced. There are now 63 gas drainage installations, 17 of which have facilities for utilising the gas. The programme is being extended, and during the next five years, the number of collieries draining gas and the quantity of gas used will both increase substantially.

It is estimated that the total quantity of methane discharged from British mines is 300 million cu. ft each day, which represents a heating value of about 1,000 million terms a year, more than a third of the amount sent out from Britain's gasworks.

The rate of emission of firedamp in the workings varies from mine to mine: in some it is small enough for the mining regulations to permit the use of naked lights underground, but in others it can be as high as 4,000 cu. ft for each ton of coal worked. Modern techniques for draining the gas from the strata in coal mines developed from experiments made in Germany during the last war. The success of the first installation in this country in 1950, which aimed at draining the gas before it entered the ventilating air, paved the way for large scale application which is still expanding.

BOREHOLES IN STRATA

Methane is a dangerous gas and is the cause of nearly all the explosions which occur in mines. Draining it away through pipes thus makes pits safer for the miners and makes it possible for otherwise gassy seams to be more fully exploited. The first attempts at methane drainage were made as long ago as the 18th century but these and subsequent experiments were nearly all aimed at removing firedamp from where it accumulated in roadways, cavities and in wastes. During the last 20 years it has become clear that coal seams will not usually yield large quantities of methane until fissured by the strata movements which occur folloing the extraction of coal, and until the pressure on the coal has been relaxed. Modern techniques now aim at extracting the gas while it is in the highest possible concentration and before it has had time to escape.

In Great Britain the technique known as the cross-measure bore-hole is most commonly used and the firedamp in the strata above or below the seam being worked is drained by means of boreholes drilled from the mine roadways into the surrounding strata. These holes are usually inclined over the worked-out area at an angle of 50 to 60° from the horizontal and are between 100 and 250 ft long. The hole is about 2½ in in diameter but the first 20 or 30 ft of each hole is enlarged to 4½ in diameter to allow a steel pipe 3 in in diameter to be grouted in with cement: this is to enable gas emission to be controlled and to minimise leakage of air through fissures to the borehole. Each hole is fitted with equipment for measuring the flow of gas and its pressure, and for taking samples; the pipe ranges which carry the gas vary in size from 6 to 10 in in diameter according to the load they carry, shaft pipes being upwards of 10 in in diameter.

Most of the methane drained is collected from conventional working of the coalface but in some pits it is withdrawn from worked out areas in which the emission of gas has continued: at only one colliery is gas drained from the seam ahead of a longwall face; in another case gas is drained from a disused mine.

If an area is filled with firedamp the rate of emission will vary with the barometric pressure and if this falls gas will be discharged into the mine airways. To counteract this, gas-filled areas may be sealed off and the pressures on the seals controlled either manually or automatically. This enables the firedamp in the sealed area to be extracted safely and at a high concentration.

AUTOMATIC ANALYSIS

Water ring sealed rotary pumps are used for extracting the gas from the mine and for pumping it into a main for utilisation. Two special gas burners are used to shut down and isolate the plant should low quality gas reach it. Other instruments including specific gravity recorders, flame calorimeters and methanometers are also used to record the quality of the gas. Audible and visible alarms operate should any abnormality such as high gas temperature or pressure occur in the flow.

The amount of methane presently being discharged from coal mines is distributed throughout the collieries of Britain according to the accompanying map. At the present, drained gas is being used at 17 collieries: eight of them send their supplies to the local Gas Boards, and nine collieries use it instead of coal in their steam raising boilers. One colliery has dual-fuel gas engines to generate electric power; small quantities are used for space heating and a certain amount is compressed into bottles for use in research laboratories and for other purposes.

The greatest activity in utilising firedamp will be in the North Western, East and West Midland and South Western Divisions. In the last of these, 13 out of 14 collieries will be producing useable gas by 1959 or the early sixties.

CATALYTIC REFORMING

Methane has twice the calorific value of town's gas and in some cases it has to be modified by catalytic reforming before it can be passed into the mains. When mixed with steam and passed over a nickel catalyst methane is converted to a mixture of hydrogen and carbon monoxide, and when this is blended with pure methane a gas having similar properties to town's gas is produced.

About 104 million cu. ft a week are now being drained, 42 million of which are being utilised in one way or another.

The best method of utilising will depend upon local circumstances but whenever possible the National Coal Board pipe it to the gas industry who can use it in a number of different ways.

HIGH TEMPERATURE HOSE IN PTFE

New couplings have been designed to go with the hose.

Prompted by demands from several British chemical manufacturers, laundry industries and aircraft accessory makers, William Rose Limited have developed a new range of flexible hoses made in ptfe. This ptfe material—ICI Fluon—has good strength and elasticity over a wide range of temperatures from − 80° C to at least 250° C. To flexible tubing, ptfe offers benefits, notably immunity from high pressure steam, resistance to all chemicals except fluorides and molten alkali metals, and a low friction, non-sticky internal surface. Compared with flexible metal tubing, therefore, this hose can not only be cleaned and used for a variety of chemicals, but its smooth internal surface creates no turbulence in the transported material.

The strength of ptfe, in comparison with most metals offers nothing to write home about, but for flexible hosing, this strength is easily provided by metal braiding. A small, specially designed tube has, in fact, withstood a pressure of 20,000 lb per sq. in, and the safe working pressures of over 1,000 lb per sq. in, quoted for the maker's standard range of sizes from ¼ to 1 in bore, should suffice for all but very demanding applications. Braiding is in stainless steel, galvanised steel, tinned copper, phosphor bronze or high tensile steel.

These hoses are made from ptfe by extrusion, and much of the development work at the Hilyn Works, Enfield, of this firm centred around attaining the correct extrusion techniques. At the same time work was proceeding on a new coupling, the result of which is the simultaneous announcement by the firm of a new patented, reuseable coupling, shown in the illustration. This provides a smooth bore, but allows contact of transported liquid with the coupling; care must be taken, therefore, in choice of alloy, for which stainless steel, mild steel and brass are offered as standard.

The primary drawback which immediately comes to mind is that of cost. Although it would be pointless to incorporate an expensive material which could be replaced by a cheaper one, two factors seem to play in the favour of the manufacturers in this instance. Firstly ptfe undoubtedly cannot be replaced by present plastics for many chemicals at high temperatures, and secondly the basic material is not so important a contributory factor in final cost as is the processing, and great strides forward in this direction have and are being made with ptfe, which are taking it out of the impossible price bracket.

The price of the standard range of hose of ¼ to 1 in bore, is, in fact, more conveniently measured in shillings per foot than in pounds per foot, and is thus on a par with flexible metal tubing.

LIQUID FIRESTOP

Intumescent protection against conflagration is offered by a fire retardant which two years ago came on to the market in the form of a powder which, it was recommended, should be mixed in a dustbin. That material was called Exolit—distributed by Exsud Engineering Limited of Cowcross Street, London, EC1, the concessionaires for a German manufacturer. That dustbin can now be used for other purposes, for the same firm is now offering the firestop as a ready-to-use liquid which comes in 1 or 2 gallon containers; one gallon, incidentally will cover about 100 sq. ft when used on acoustic board, or over twice that area on soft fibre insulation board.

Exsud emphasise the fact that the compound has stood the test of all tests—an outbreak of fire. It has been used widely in Britain by a number of firms, among whom are Jaguars of Coventry who have now treated almost half a million sq. ft of fibre insulation board.

It will be recalled that this intumescent compound provides a rating of Class 1 of BS 476: 1953 relating to the spread of flame on surfaces, which in effect means that surfaces so treated will not support combustion.

NEW FRICTION MATERIAL

MW48 is a solid woven asbestos friction material made specially for oil well drawworks. Impregnated with a synthetic resin, this material has good bolt holding capacity as the result of the inclusion of fine brass wire reinforcement in both warp and weft yarns on the band side of the material adjacent to the non-working face.

It is made by Ferodo Limited, of Chapel-en-le-Frith, Derbyshire; with a medium/high coefficient of friction, it is said to possess all the rugged characteristics required for drilling operations. It has good frictional stability, resistance to fade, long life, drum kindness, and does not smoke or burn.

Ferodo MW48 is normally supplied undrilled in radiused blocks of standard size and thickness with a ground working face. It can also be supplied drilled to customers' specifications, or machine grooved for fitting by the Ferodo Ferolok or American Key-Lok methods of easy attachment and replacement.

HAIR PACKAGING MATERIAL

Visitors to the Packaging Centre in Poland Street, London, W1, will soon realise that the protection of goods in transit is becoming quite a "science"; vapour phase inhibitors, protective coatings, and wrapping papers and films are only some of the subjects on which there is much information and experience on which to draw. This organisation, incidentally, offers a free information bureau to industry.

Among the materials which have recently made an appearance there is a synthetically bonded hair packaging material. The nature of the adhesive is, in fact, the main difference between it—Tuflite, and the established rubberised hair material called Xetal; needless to say, both are made by Xetal Products Limited, of Speke Hall Road, Liverpool.

The ghosts of many fine hogs will feel for their earthly comrades if this material becomes popular, for although employing a new adhesive, Tuflite is in fact based on a supply of curled hogs' hair. The new bonding agent has allowed a packaging material to be made which is more chemically inert, and has less weight than a rubberised hair offering the same protection. It comes in the form of sheets from 1 to 4 in in thickness, or can be supplied in moulded forms. Use of such materials becomes important whenever (and this means usually) goods are likely to be dropped from heights of several feet on to hard floors, when the deceleration is likely to reach several hundred times the acceleration due to gravity.

A booklet prepared by Xetal permits easy calculation of the packaging required. It is only necessary to know against how many drops from what height it is required to protect an article with a known "fragility factor," for a determination of how many hog obituaries must be written.

INFORMATIVE CABLE PUBLICATIONS

"Copper, by virtue of its high conductivity and other excellent properties, has always been the electrical designer's ideal conductor material."

"We believe that the time is opportune for a new and radical approach to cable design to obtain the best possible advantage from the use of aluminium in conjunction with plastic insulants. More than 200 miles of insulated cables with aluminium conductors were installed in Great Britain and France between 1909 and 1913. Aluminium now has an accepted place in the electrical industry."

"Each year the electrical industry absorbs almost one-half of the world's production of copper, a figure which exceeds four million tons. Metals of lower conductivity than copper can only be utilised at the expense of an increase in the overall size of each piece of electrical equipment."

"The output of the non-ferrous metals other than aluminium is not keeping pace with the general increase in production or the output of electrical energy. Between 1930 and 1953 the generation of electrical energy throughout the world increased by 160 per cent whereas the increase in production of copper was only 25 compared with 300 per cent for aluminium."

"The purpose of this booklet* [however] is to describe and illustrate many of the more important of the infinite number of types and designs of cables, in the construction of which copper plays such a vital role. For convenience, the various types of cables have been subdivided into power, telephone and miscellaneous designs."

"Purchasers have their own ideas of the magnitude of the [price] differential needed before they consider a changeover [to aluminium] justified, and this figure shows considerable variation. We believe that there are strong technical reasons which by themselves afford justification for the use of aluminium, and in the following pages† we describe a number of applications for which its use has been decided on merit alone."

The jury will adjourn to consider its verdict.

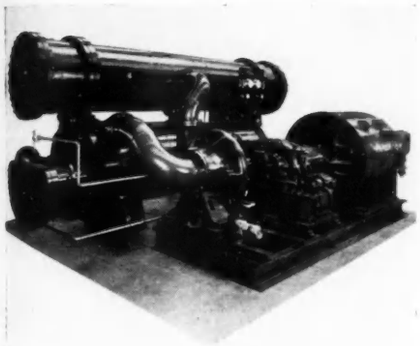
* *Copper Cables*, published by the Copper Development, South Audley Street, London, W1, (1959).

† *Aluminium for Insulated Cables*, published by Aluminium Union Limited, John Adam Street. London, WC2, (1959).

PACKAGED WATER CHILLING

Self-contained, packaged water chilling sets have been despatched by York Shipley Limited for use in the air conditioning services of the Ahmadi Hospital, now being built for the Kuwait Oil Company in Kuwait. The equipment being supplied by York Shipley comprises two single-stage turbo-compressor chilling units using Arcton 9 (Freon 11) as the refrigerant. Each unit is rated to cool 875 gallons per minute, recirculating water chilled from 53° F to 45° F. This represents a heat removal of 4·2 million Btu per hour. The automatic starting and stopping of the plant comprising an infinitely variable control of capacity between 5 per cent and full load.

Power for the York compressors is obtained from Bruce Peebles motors which were purpose



designed to suit local electricity supply conditions. The speed is stepped up through David Brown gearboxes. The evaporator and condenser are of the horizontal multi-pass shell and tube pattern with side connection boxes. The combined units, which are shown in the illustration, occupy a floor space of 11 ft 6 in by 20 ft.

In both the design of the condensers and the selection of the materials used, special consideration had to be given to the problems arising from insufficient water supplies, which are overcome by using seawater for their cooling.

Arcton 9, the refrigerant used, is both non-toxic and non-inflammable, thus presenting no hazards in operation; it also possesses low pressure characteristics that make it easy to handle.

EASIER HANDLING OF TRAWLS

A rational solution to the problem of centralising and mechanising the handling of a fishing trawl over the aft end of the vessel, as well as of handling of fish into the 'tween decks where the factory operations are carried out, has been devised by MacGregor International in conjunction with James Robertson and Sons (Fleetwood) Limited.

The proposed trawling unit comprises a shroudless bipod mast with two symmetrically situated units for loosening, controlling or raising the trawl. Each unit consists of a rotating crane, with a 3 ton lift and 16 ft range, and a fishing winch with brake and warp guiding gear. The hatch space under the mast is closed by watertight steel covers, flush with the deck; the covers are hinged and fitted in a frame to form a mobile ramp which eases the problem of lowering the fish to the 'tween deck. Should the cranes break down, they can be rotated by winch and a longitudinal beam located forward of the bipod mast which together form a standby hoisting method.

Among the advantages claimed for the system is a valuable gain of space on the weatherdeck, which then becomes available for cabins and frees the 'tween decks for gutting, packaging and deep-freezing of fish. Crew safety is improved in high seas and the elimination of the conventional stays to the mast reduces the risk of icing, with its accompanying increase in top weight. Reduction in crew number is also possible because of the increased mechanisation.

A model of the unit was shown at the recent World Fishing Boat Congress held in Rome and a descriptive leaflet is to be had from either Robertsons at Fleetwood or MacGregor International, 96 Rue du Ranelagh, Paris XVIe.

LORRIES WITH ELEVATING BODIES

The lightness of aluminium, already widely appreciated in the manufacture of commercial vehicles, is of even greater importance in a new range of vans and trucks designed by Rootes Motors Limited of Ladbrooke Hall, Barlby Road, North Kensington.

The new range, designated " Cargo Lift," was designed primarily for aircraft loading and servicing. The vehicles have a conventional four-wheeled chassis and cab, but the body is attached by pairs of scissor-like linkages. Lifting power is provided by two hydraulic rams interposed between a chassis cross-member and a cross-bar on the scissors links, enabling the body to be raised to any height up to a maximum of 10 ft 4 in or 13 ft (according to type).

A further refinement is available in the form of a hinged platform extending forward over the cab of the vehicle to the aircraft loading hatch. This platform is guided by rubber wheels engaging in curved channel members attached to the cab. As the body is elevated, the rubber wheels follow the guides until the platform is horizontal, when they disengage from the channels and the platform remains in the horizontal position, rising with the body. Lowering automatically brings about the reverse action. An alternative forward platform is of the cantilever type mounted horizontally above the cab. It rises with the body once the floor has reached the level of the platform.

Two basic variations of the vehicle are available: a van body mounted on a Commer five-ton chassis/cab (as illustrated), and a truck body mounted on a Karrier Gamecock chassis/cab. Refinements available include a power-operated tailboard lift for the van body and a folding auxiliary side-loading bridge.

It is obviously important that the body should be as light as possible, and the body builders, Wilson and Company Limited, of Solihull, Warwickshire, therefore make wide use of aluminium alloys in its construction. Noral has been used for the top-hat extruded sections and the panelling used in both the van and truck. Suppliers of the aluminium alloys are the Northern Aluminium Company Limited.

Fourteen of these vehicles have now been built and are in service with several airlines. One of the operating companies reports that the unit has reduced commissary equipment and handling time by as much as 50 per cent.

LIQUID WHISTLE HOMOGENISER

The Minisonic homogeniser has been developed as a small versatile unit selling at a low price. It has been designed for making up small quantities of emulsions and dispersions, and is able to handle 3 litres at one filling without external premixing. As such it is well suited for laboratory work, for hospital dispensaries and the cosmetics industry, and as a pilot plant homogeniser in which an emulsification process can be worked out on a small scale.

The Minisonic, which is shown in the illustration, works on the principle of the liquid whistle, an efficient method of utilising cavitational forces in liquids. Briefly, a thin blade is made to vibrate in a liquid stream at a frequency of 18 to 22 kc/s, which is inaudible to the human ear and of such a high energy level as to induce cavitation. Intimate mixing is thus brought about, resulting in a truly homogeneous emulsion of very fine particle size. Four distinct methods of use are possible:

(*a*) gradual emulsification, useful when the dispersal phase approaches the limit or when there is a danger of reversal in the emulsion system; (*b*) instantaneous emulsification; (*c*) one

pass homogenisation for the sonification of premixes, and (*d*) multiple transfer of emulsions and organic dispersions which yield better results when sonified more than once.

All parts in contact with the liquids are of 18/8 stainless steel or other corrosion proof materials; all surfaces are polished to assist with cleaning and the built-in glass vessels make for easy operation and speedy dismantling. A finger tip control valve is fitted and the unit is sold ready for plugging into a 15 amp 3-pin socket.

The Minisonic is made by Ultrasonics Limited, Otley, Yorkshire.

STANDARDS CONFERENCE

A one day conference of engineers and others interested in the application of standards to industry was held in London on Thursday, 4 June. The Institution of Production Engineers and the British Standards Institution were jointly responsible for the arrangements and the meeting was chaired by Mr. H. A. R. Binney, C.B., director of the BSI.

After an opening address by Lord Halsbury, President of the Institution of Production Engineers, a talk was given by Mr. S. T. Robinson of S. Smith and Sons (England) Limited, entitled " Operation of a Company Standards Department." The morning sessions was concluded by Mr. Bertram White of A. Boake, Roberts and Company Limited, who dealt with the application of standards in the firm; simplification; the place of the standards engineer in the organisation of the firm.

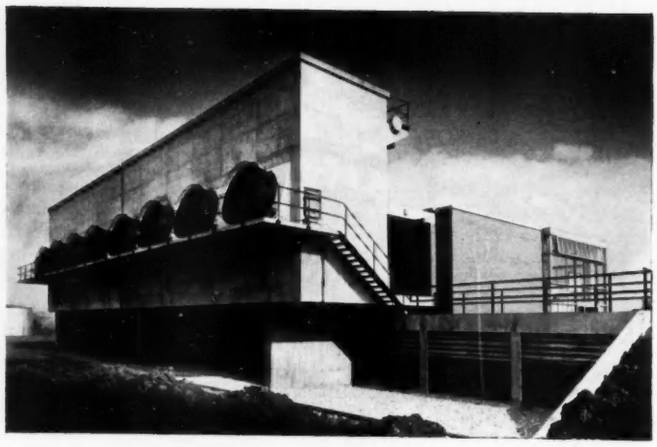
FEEDING HEAT BACK TO THE PROCESS

Effecting Economy in Food Production

An essential operation in the production of tinned foods is sterilisation. At the Kitt Green factory of H. J. Heinz Company Limited, this phase of the process is associated with a heat recovery system that introduces valuable economy into the overall operation of the factory. The architectural coordination and design of the factory was the subject of an article published in our issue of 1 May, page 576.

Sterilisation at Kitt Green takes place in two stages. The filled tins are inserted into retorts and surrounded with steam from the main steam system, then, to bring about rapid cooling, sterile cold water is flushed through the retorts. The cooling water leaves the retorts and gravitates through to the heat recovery units and hot wells —it is afterwards pumped to forced draught coolers for recirculation. The complete heat recovery system makes use not only of retort cooling water but also of flash steam from the other steam using plant. The system was developed by Heinz at their Harlesden factory, and the result is that large quantities of water are gradually warmed by waste heat through the early part of the day and used for washing down in the late afternoon. The installation at Kitt Green, shown in the diagram, was designed by G. H. Buckle and Partners, 2 Harrington Gardens, London, SW7, who were mechanical and electrical consultants to the whole project.

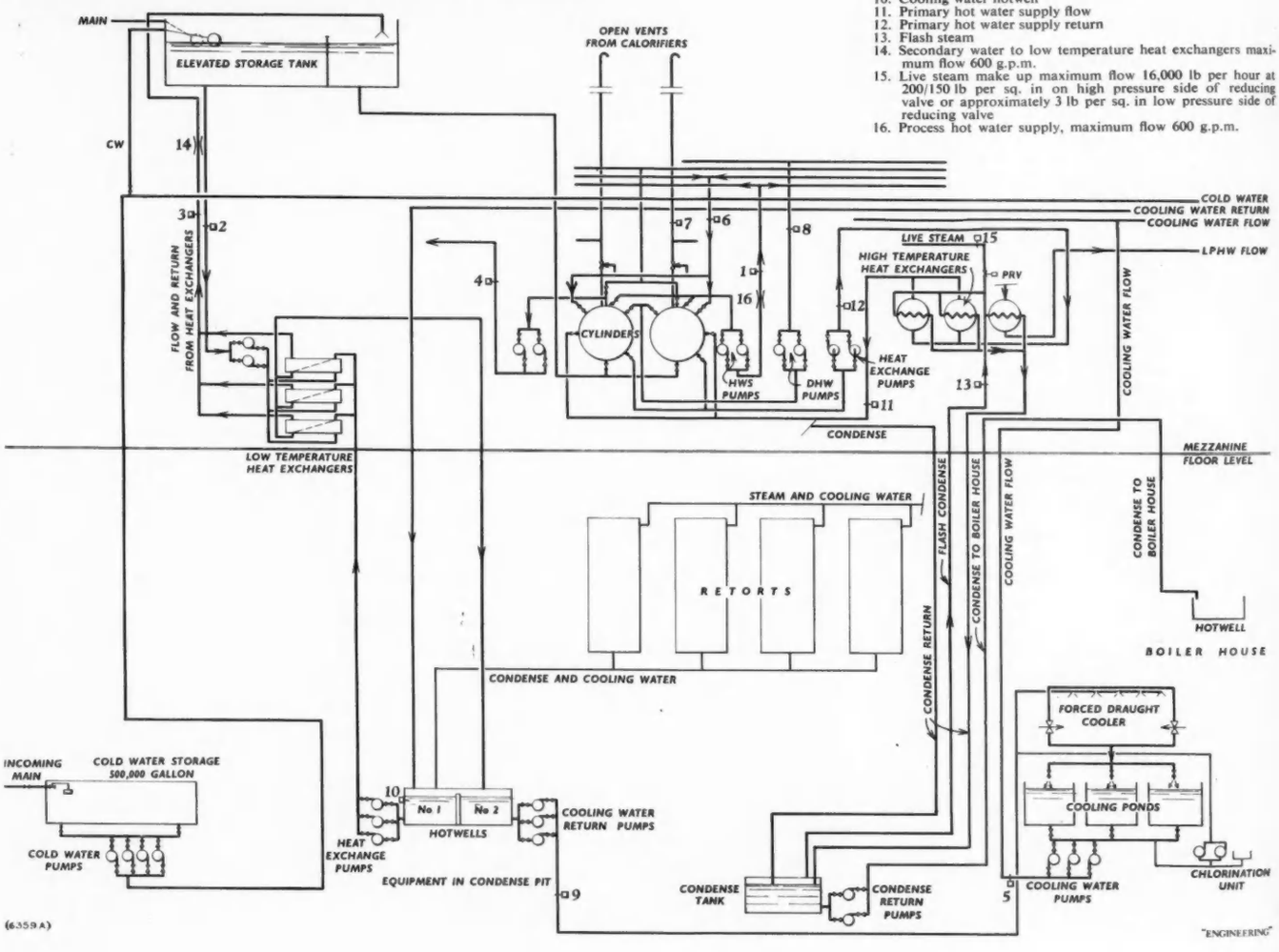
Process hot water for the system is fed to a storage tank on the roof of the main production building. The tank has two compartments and holds 20,000 gallons. Water is warmed in three double-bank non-storage heat exchangers associated with the cooling water from the retorts and returned to the second compartment of the tank. During this cycle the water is warmed to about 100° F, each heat exchanger having a capacity of 3·75 million Btu per hour. The warm water is then pumped into a circuit containing eight 2,750 gallon storage cylinders and the three heat exchangers of the flash steam system. The heat exchangers have a capacity of 4 million Btu each, and the water in the cylinders reaches a temperature of about 180° F. From the cylinders the water is pumped to the



(Left) The cooling plant cools, clarifies and sterilises recirculating retort cooling water.

(Below) Diagrammatic arrangement of heat recovery plant.

1. Process hot water supply flow
2. Low temperature heat exchanger secondary flow
3. Low temperature heat exchanger secondary return
4. Process hot water supply flow for can washing
5. Cooling water flow to production building
6. Process hot water supply return
7. Domestic hot water supply flow
8. Domestic hot water supply return
9. Cooling water return to ponds
10. Cooling water hotwell
11. Primary hot water supply flow
12. Primary hot water supply return
13. Flash steam
14. Secondary water to low temperature heat exchangers maximum flow 600 g.p.m.
15. Live steam make up maximum flow 16,000 lb per hour at 200/150 lb per sq. in on high pressure side of reducing valve or approximately 3 lb per sq. in low pressure side of reducing valve
16. Process hot water supply, maximum flow 600 g.p.m.



TOWARDS CALCULATED CONTROL

Integration of Design and Operation in Process Engineering

In the last 20 years, largely under the impetus of the demands of war, there has been considerable development in the theory and practice of mechanical control. Servomechanisms, developed for naval gunnery control, have been extended to the solution of many problems encountered with guided missiles. The dynamic characteristics of moving parts can be predicted and the response and stability of the whole system under control may be tested by calculation or simulation by an analogue device. Complex though such control systems may be, the prediction of their response is, in general, simpler than those involving chemical reactions. It is in the field of chemical process control that the engineer faces a tremendous challenge as he looks towards the far distant goal of the completely automatic process. How computers may assist him was very much the theme of the joint symposium " Instrumentation and Computation in Process Development and Plant Design " which reported developments both in mechanical and chemical process control.*

* The Symposium, held in London on 11, 12 and 13 May, 1959, was organised by the Institution of Chemical Engineers, the Society of Instrument Technology and the British Computer Society; the proceedings are to be published in full.

In assessing the best control systems, the engineer must know the response of each element of the control loop. Only then can the relevant controllers be set to " cooperate " with the units they are required to control. Typical process elements are flow systems, heat exchangers and mass transfer units such as distillation and absorption columns in which purely physical operations are performed. With chemical reactors, account must also be taken of the reaction kinetics. A change in operating conditions may favour a side reaction with consequent product contamination and loss in yield. Then, not only must the control contend with the inertia of mass and thermal flows in a complex physical system, when response to a disturbance may be far from linear, but also it should be capable of optimising the reaction kinetics.

Checking Response

Often it is possible to assess the dynamic response of equipment by breaking the control loop and deliberately injecting a sinusoidal disturbance through the valve controlling the relevant process condition. The investigator notes the attenuation and phase lag suffered by the disturbance in travelling through the plant as a function of its impressed frequency and so gauges controllability. If the disturbance is superposed upon the normal control action, analysis is more complicated. A study was described in the symposium where the dynamic response of a heat exchanger was assessed by the analysis of variations occurring under normal cunning conditions. The lengthy calculations for the correlation analysis were more readily possible with the use of a large calculating machine. Such studies on existing equipment may suggest modifications to the control loop, particularly where the measuring element is at fault, but largely it only provides experience for the improvement of future equipment.

Many attempts have been made to predict the dynamic response of process equipment while it is still in the design stage so as to ensure that the resulting equipment shall be amenable to control. Physical units such as heat exchangers and distillation columns have been widely studied. Detailed calculations, however, of even the steady state relationships between the independent variables of a distillation column (such as the rate, temperature and composition of the feed; feed point, number of theoretical stages and reflux ratio for the column) and the product quality are exceedingly laborious yet are essential to an understanding of the controllability of the column. Studies, made possible by use of a large digital computer, which will assist in the choice of method of control according to the particular product requirements were reported. Of still greater interest for successful control will be the assessment of the dynamic response to disturbances in, for example, feed temperature, feed composition or reboiler heat supply. In general, theoretical work has been limited by the complexity of such systems. However, work showing good correspondence between a comparatively simple electrical analogue based on Voetter's theory and the response of experimental distillation columns was described. Though not of high accuracy, this promises to be a very valuable means of testing proposed control schemes for distillation columns.

The control engineer faces the additional problem that it is not yet possible to specify the optimum kind of controlled behaviour; this is largely due to the scarcity of reliable knowledge about the disturbances generally encountered and the need to accumulate experience of these is very pressing.

Reaction Control

Too often control is effected from an inferential measurement. Product quality may be gauged from a combination of measurements such as the flows to a reactor and the reactor temperature. Periodically the accuracy of this is checked by the analytical service laboratory. Product yield is naturally important but so too may be trace impurities. Continuous analytical monitoring of the process stream is potentially much more satisfactory than inferred judgment of quality. At present much work is being done developing suitable instruments. In simple applications, thermal conductivity devices have been most valuable. Continuous stream infra red spectrometers are in increasing use and the recently developed method of gas phase chromatography promises well as a reliable specific quality control instrument. Many other types of continuous analytical instruments are, or are becoming, available.

The application of these monitoring instruments to physical control presents comparatively few problems. When they are detecting variations in a chemical reaction the control requirements are, as mentioned above, far more complex. Optimum control, for example, may require the adjustment of reactor temperature and reactant residence times as the catalyst ages. For such systems, the conventional controller will be far from adequate though very ingenious systems have been developed with comparatively simple control devices. Future requirements will demand the extension of analogue and the introduction of directly linked digital control systems.

So many variables may affect a chemical process directly or indirectly that often the optimum operating conditions cannot readily be predicted from experience of the process in operation. At the meeting, the present value of statistical considerations in an empirical approach to the optimum process operating conditions was reviewed. This drew largely on methods developed by Professor G. E. P. Box for the investigation of process response surfaces. When use is made of them in their widest form, the determination of the coefficients of the response surface of the multivariate space can be laborious without a machine programme.

Improvement by Reiteration

The approach to the optimum is checked by significance tests from fractional factorial designs. These methods are adapted in so-called " evolutionary operation " where programmes of small planned operational changes in a few variables are introduced. The changes are designed to be insufficient to affect the process greatly, yet to be sufficient to indicate in which direction changes should be made in order to improve the process. Having found the direction of changed variables in which improvement lies, the series of experimental operating variations is extended, centred on the improved set of conditions, and further improvement sought. Thus operation evolves until the optimum is achieved.

With a complicated process this may well take many months for sufficient operating experience to be accumulated but the process is continually being improved. The technique can be applied quite readily by men with little knowledge of statistics and quick methods have been developed

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Concluding

Feeding Heat Back

production area by a 600 gallon per min pump, against 120 lb per sq. in. The pump is a three-stage high-lift centrifugal type, and like most of the pumps in the system was supplied by Worthington-Simpson Limited, P.O. Box 17, Newark, Notts.

The cooling plant that cools, clarifies, and sterilises re-circulating retort cooling water was designed by John Taylor and Sons, Artillery Row, London, SW7. The rate of flow in the circuit is determined by the demand from the factory and is controlled by a rate of flow venturi meter. A maximum rate of 110,000 gallons per hour can be handled. Cold clear water tanks are located under the pump and filter house, situated north-east of the main production building, and three pumps are available to pump the water to the retorts. Each pump has a capacity of 600 gallons per min.

The coolers, shown in the illustration, consist of 8 reinforced concrete forced-draught cooling compartments, which reduce the temperature of the water to a maximum of 70° F. Visco Engineering Company Limited, Croydon, Surrey, supplied the water cooling plant. The concrete shell is 100 ft long by 13 ft wide by 18 ft high, each of the 8 compartments being provided with timber irrigation, a 6 ft diameter fan, and an 8 h.p. motor.

Water from the coolers collects in a balancing tank of 35,000 gallons capacity, integral with the cooler structure, from which it gravitates to a filter inlet channel. Flow into the filters is regulated by a double-beat equilibrium valve controlled from the level in the balancing tank. There are 5 rapid gravity filters and from these the water flows over a measuring weir and back to the clear water tank. Automatic shutdown of the filters occurs to prevent the clear water tank overflowing when the circulating pumps are stopped and the level is high; water is then stored in the balancing tank. As the quality of the water being recirculated is indefinite, the chemical gear has been designed to give the utmost flexibility in treatment.

for estimating confidence limits on the changed response. One paper looked to the future when a digital computer receiving all process measurements and initiating overall control may be programmed to introduce minor disturbances so that the reaction response will be explored automatically.

Control Media

In general, process control today is largely effected pneumatically. Developed empirically to a high degree of reliability, those basic computers, the proportional controllers with or without the addition of integral, derivative or inverse derivative actions, position the control valves by signals within their working range of 3 to 15 lb per sq. in. This has become the accepted standard. Specialised requirements make their own demands; a very large and critical control valve may well necessitate the greater expenditure on a hydraulic system.

Multifunction relays are available for compounding pneumatic signals but the ease with which electrical signals may be handled makes an electrical system attractive, and also most continuous analytical instruments develop an electrical signal. A simple electrical computer, which in principle is an electromagnetic balance, is already available quite cheaply. It is capable of evaluating

$$(ax \pm by)\, cz \pm s + (pu \pm qv)\, rw = 0$$

where a, b, c, p, q and r are fixed or adjustable coefficients, s is developed by a spring and x, y, z, u, v and w are variables of which any one may be the output variable. With this, an inferential flow measurement can be readily corrected to give a linearly scaled true mass flow by extracting the square root of the differential pressure and correcting for fluctuating gas density by compounding with an additional pressure measurement. Ratio control can be improved, simple simultaneous quantity equations solved, and so on. Most electrical systems use current variations in the milliamp range as the basis of the control signal. The possibility of frequency variations has been little explored. No general electrical standard has as yet emerged. The desired controller characteristics are still a matter of discussion. Consequently, a wide range of electrical control equipment is being manufactured and its price, in general, is significantly higher than the pneumatic. The price of finding a satisfactory standard is likely to be quite high but the cost of not finding it could be exorbitant in the future.

For the present, the application of analogue methods to the study of process control is being rapidly extended. From these studies, leading to preliminary optimisation, the digital computer may be employed in a more precise yet less flexible evaluation of response. There is still much work to be done in the improvement of the characteristics of measuring and control elements before, in a complicated process, expenditure on a direct linked digital control is warranted.

In this country a comparatively small transistorised digital computer, suitable for direct control of power plants, steel rolling mills, simple chemical processes and so on, is available. Within its programme it can be arranged that it will frequently check all its functions and, under test conditions, a prototype has simulated the control of a plant for over a year without failure. Similar experiments are being made in the United States but there, recently, the president of an instrumentation and control company expressed the hope that there would not be undue haste in the installation of digital computer control before reliability was well proven. He feared that, as in other fields in the past, a few failures through too early introduction may prejudice potential users against fully "calculated control." Calculated control is becoming a reality in the design stage; as the precision of prediction improves the development to utilisation of calculated control in operation is likely to be feasible and economically justifiable.

THE VISCOUS DAMPER *and its* VECTOR DIAGRAM

By G. S. PIDD, B.Eng., A.M.I.Mech.E.,
Lloyd's Register of Shipping, London

A viscous type torsional vibration damper can be considered as consisting of a casing having an amplitude $\bar{\theta}_c$ radians containing a rotating mass of moment of inertia J_r lb-in-sec^2 having an amplitude $\bar{\theta}_r$ radians. Between the casing and rotating mass is a viscous fluid giving an effective viscous torque of k lb-in per radian per sec relative speed of rotation.

The phase velocity of the torsional vibration of the engine for which the damper is intended is p radians per second.

The inertia torque of the rotating mass is then $J_r p^2 \bar{\theta}_r$ and is identical to the friction torque $k\, p\, (\bar{\theta}_c - \bar{\theta}_r)$. These vectors are shown in Fig. 2.

Optimum Conditions

Under optimum conditions of damping, when $\frac{J_r p}{k} = 1$, the triangle shown in Fig. 2 becomes an isosceles triangle and the work per cycle,

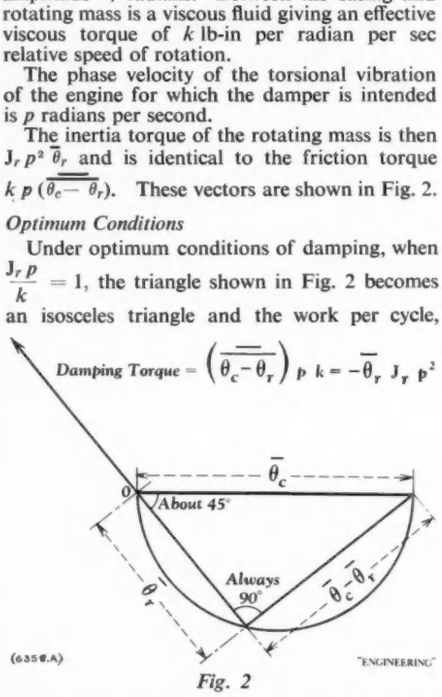


Fig. 2

which is proportional to the area of the triangle, is a maximum. Neglecting engine damping the optimum dynamic magnifier of the engine-damper system at resonance is

$$M_{DO} = \frac{2 \Sigma J_1 a_1^2}{J_r \theta_c^2}$$

J_1 and a_1 refer to the inertia and specific amplitudes of the engine masses respectively.

The corresponding amplitude of vibration is given by $\theta_0 M_D$ where θ_0, the equilibrium[1] or basic amplitude $= \frac{T n \Sigma B n}{p^2 \Sigma J_1 a_1^2}$ radians and T and $\Sigma B n$ are the harmonic torque per cylinder and vector summation of cylinders respectively.

Non-optimum Conditions

If k or p vary from the optimum such that $\frac{J_r p}{k} = X$, the lengths of the two smaller sides of the vector triangle are in the ratio of X : 1, see Fig. 3. Thus the area of the triangle is reduced and in general

$$M_D = \frac{2 \Sigma J_1 a_1^2}{J_r \theta_c^2} \times \frac{1 + X^2}{2X}$$

It will be seen that adequate damping can be provided even though optimum conditions are not obtained.

Engine Damping

This is conveniently dealt with by assuming an engine magnifier M_E based on measurements taken from a large number of engines of numerous types[2] given by

$$M_E = \frac{120}{\sqrt[4]{\theta_0 \times 10^6}}$$

This leads to an approximate formula for the

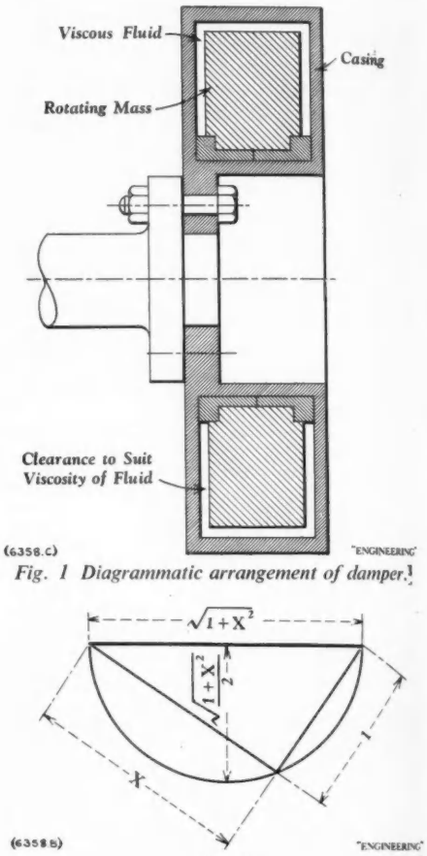


Fig. 1 Diagrammatic arrangement of damper.[1]

Fig. 3

magnifier M_{ED} which takes into account engine and damper damping with allowance for reduced engine damping when the damper is fitted.

$$M_{ED} \simeq \frac{M_D}{1 + \frac{M_D}{300} \times \sqrt[4]{\theta_0 \times 10^6}}$$

This formula can be corrected by means of successive approximation.

Amplitude—r.p.m. Curve

It is little practical advantage to endeavour to calculate the precise critical speed for an engine to which an effective damper is fitted as often a clearly defined resonance point does not exist.

It is usually sufficiently accurate to use a general magnifier M_G for flank amplitude

where $\frac{1}{M_G} \simeq \sqrt{\frac{1}{M_{ED}^2} + \frac{1}{M_U^2}}$

and $M_U = \frac{1}{1 - \left(\frac{\text{actual r.p.m.}}{\text{resonant r.p.m.}}\right)^2}$.

References

[1] W. Ker Wilson, *Practical Solution of Torsional Vibration Problems*. Chapman and Hall (1940).

[2] S. Archer, *BICERA Handbook on Torsional Vibration*, p. 353. Cambridge University Press (1958). [Note: $\theta_s (= \theta_0)$ should be 10 times larger than given in handbook]

The complete article giving the derivation of the above formulae can be obtained, price 25s, from the author at 72 Broadmead Road, Woodford Green, Essex.

VERSATILITY IN PRODUCTION

Not so many years ago welding was regarded as a means of recovery of defective castings and a convenient method of producing odd parts which were not complex in design and, with no likelihood of repetition, provided little justification for the cost of a pattern.

Now that higher speeds with heavier loads are possible in machines of smaller compass, fabricated gear cases and other components are necessary which are capable of withstanding these conditions. This applies particularly to gears and gear units which, together with a diversity of other products ranging from an Aston Martin car chassis to 36 in pipeline valves, are used by David Brown Industries Limited. To produce these parts efficiently, to the required standards, all David Brown steel fabrication work has been concentrated in an entirely self-contained factory at St. Andrew's Road, Huddersfield, about two miles from the parent organisation.

The first step in the organisation of these works was the establishment of a drawing office staffed with specially trained men. Here the shape of every piece of steel is developed and full size detail drawings are prepared for use as masters for automatic cutting on an electrically controlled, twin carriage Hancomatic oxygen cutting machine which has a capacity of 13 ft and is easily capable of extension as and when necessary. It will cut steel plates up to 12 in thick and the parts produced are of such accuracy that they will fit into place without further cutting after folding.

The manufacture of gears of so many sizes and types for every industry has given the David Brown Organisation excellent scope and opportunity for developing special designs based on the welding technique instead of merely fabricating wheels from casting drawings.

" H " arm wheels, which have given such long service as steel and iron castings, possessed considerable advantages in that they were rigid and could be made from coreboxes and strickles, thus minimising pattern making costs and pattern storage problems.

Early attempts at fabrication from steel plate followed this design, but later experience has shown that the box section arm is a more practicable manufacturing proposition, gaining in rigidity without increasing the resonance. Fig. 1 shows two gear blanks and one finished wheel of this type.

Each arm comprises two " U " sections which, after cutting to size and annealing, are bent cold to shape on the 1,000 ton Fielding and Platt vertical press shown in Fig. 2. This machine is capable of working up to 3,000 lb per sq. in, and the 10 ft between uprights gives it ample capacity. Press tools, which are made in the department, are now available for all normal requirements. After shaping, the arms are electrically welded to the boss which has been flame cut from the solid. Present facilities provide for cutting out bosses up to 30 in thick and will shortly be available up to 50 in thick.

Rolling the rim from a flat section is a particularly interesting operation which is carried out on a Henry Berry 600 ton horizontal press, capable of rolling sections up to 4 ft 6 in wide by 3½ in thick and bars up to 8 in square. These are not hard and fast figures as the width capacity is naturally governed to some extent by the thickness of the plate which can be manipulated with the maximum pressure of 3,000 lb per sq. in.

Fig. 3 shows this operation in progress. It will be noticed that there are no clamps as the plate is constrained between the rotary table and the two upright rollers which are adjustable to suit each radius involved. The use of comparatively short templates and the acquired dexterity of the operatives makes this a simple and most efficient process. Lifting of the overarm by a motor and Radicon reduction gear facilitates the removal of the complete ring for a wheel which is not required to be in halves.

Stress relieving is carried out in a 16 ft by 10 ft recirculating type annealing furnace, supplied by Modern Furnaces and Stoves Limited, which is fully controlled by six pyrometers; a recording panel gives a check on the temperature maintained through the whole period of treatment.

FLAW DETECTION

To find laminations in the rims during the cutting of the teeth would be intolerable and some non-destructive method of inspecting the rolled plate is essential. The use of radiography on pieces of the dimensions involved is not practicable, but excellent results have been achieved by the untrasonic method of flaw detection. This operation, though it is a routine check, is always carried out by one of the metallurgists, as it requires both skill and experience to determine the correct positions for the probes to get a complete scanning of the material,

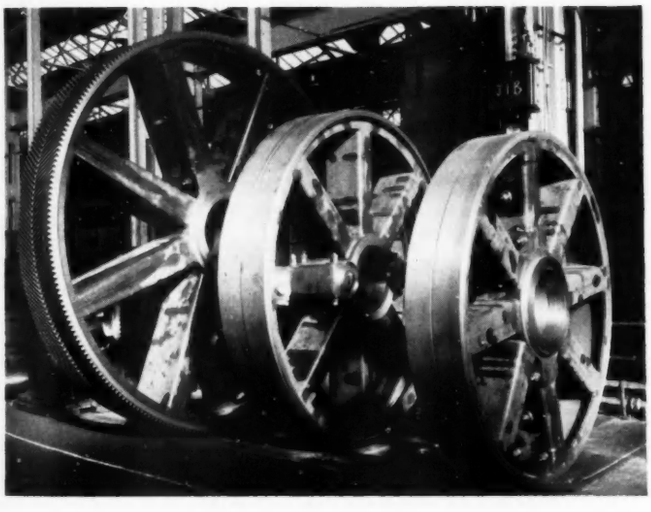


Fig. 1 (left) Gear wheels and blanks designed for fabrication.

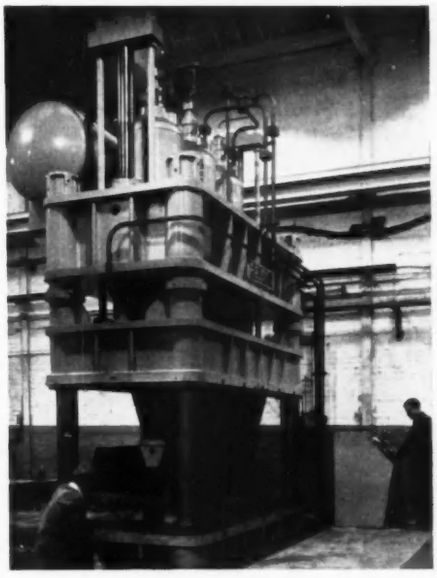


Fig. 2 (right) Folding " U " sections on 1,000 ton press.

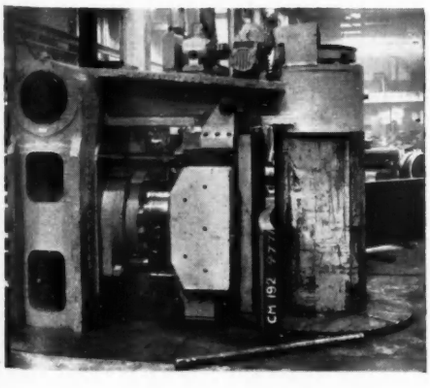


Fig. 3 (left) Wheel rim rolling on 600 ton horizontal press.

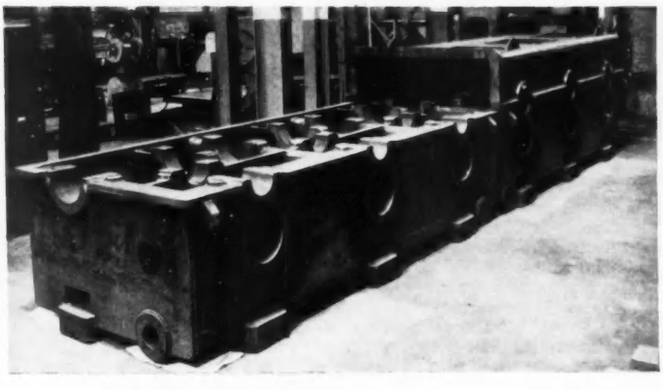


Fig. 4 (right) Fabricated box for combined spiral bevel and helical six-roll unit.

Fig. 5 (above) Axle cases for Toronto underground trains.

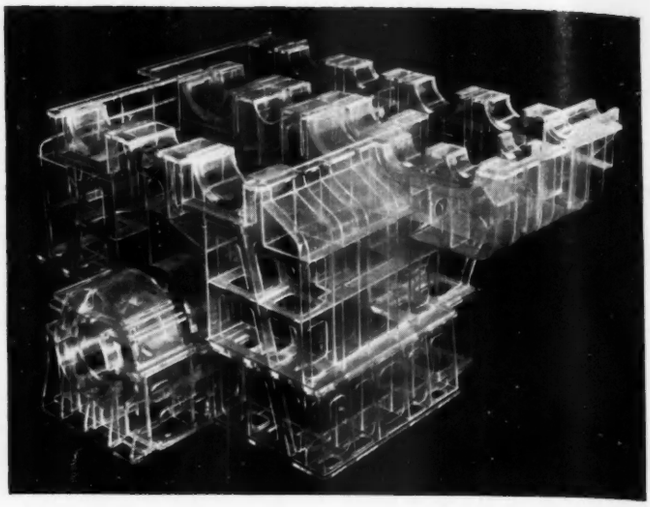


Fig. 6 (above) Perspex model of frigate gear case.

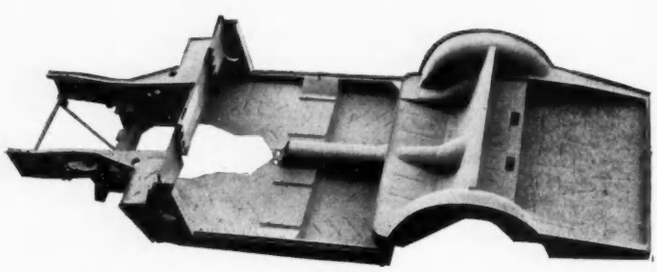


Fig. 7 (left) Aston Martin car chassis.

Fig. 8 (right) Building up a valve body by welding together three cast sections.

and for the proper interpretation of the oscillograms.

Fabrication of steel cases followed a similar process of evolution in that earlier examples were made to designs prepared for castings, resulting in an over-abundance of plates welded together and on to a flanged base. Fig. 4 is an example of the latest technique applied to a complex structure which forms the case for a combined spiral bevel and helical 6-roll unit. The main framework is made from a plate bent to a flat-based " U " section with pads and pockets for holding-down bolts. End plates are welded in place separately and with the top half, shown in position on the rear half of the case, fashioned in similar " rigidfold " manner, the whole structure is neat, compact and of immense strength. The bearing bosses are flame cut to shape as are the independent bearing caps for the inner bearings.

Not only for stationary plant, but also for transport applications, full use has been made of the many advantages of steel plate fabrication. Fig. 5 is a good sample of this latter type of work. The cases are for the spiral bevel axle drives of Toronto underground trains and the testing of the prototypes, made before full production was commenced, showed that they generously fulfilled the requirement for strength and rigidity with strict limitation on weight and bulk.

An unusual example of extraordinary complexity was presented by the main propulsion gearcase for a frigate and here the exceptional step was taken of preparing a Perspex model of the case so that the accessibility of all the welding areas could be determined and a cutting and building sequence laid down. While with this material photography is difficult, due to reflections and refractions with the multiplicity of plates, Fig. 6 gives a good idea of the work involved. It has proved well worth while since production requirements have necessitated the supplementing of the David Brown output by cases made elsewhere.

A separate department has been set up at these works for the fabrication of the chassis members of the Aston Martin car. This involves techniques in jigs, spot welding, pressing and welding which are too complex to be dealt with fully in this article, but Fig. 7 shows the quality of work which is being turned out.

Another aspect of the work covers the direct association between the company's steel foundry at Penistone and the Welding Division. A typical example is illustrated in Fig. 8 where a 24 in pipeline valve body has the three cast sections joined by submerged arc welding.

Storage and handling of stock plates require a substantial amount of space and it has been found necessary to maintain stocks of both EN8 and EN14B steels. Mild steel stock covers many sizes from 20 gauge up to 13 in thick and alloy steel is held from 1½ in to 4 in plate.

Propane/oxygen is used to give a long flame and acetylene/oxygen for a hot flame; certain jobs benefit by the use of both methods.

Other facilities which show the value of centralising jobs requiring parallel or at least associated skill are four flame hardening tanks and a special automatic machine for flame hardening the teeth of sprockets up to 3 ft diameter for tanks and tractors.

A small but nevertheless vital consideration is the storage of welding rods without deterioration and a special bonded store has been built where the temperature is controlled at not less than 70° F and humidity is maintained below 40 per cent.

WORDS INSTEAD OF DRAWINGS

Increases in production ranging from 20 to 100 per cent are claimed when using the audible instruction system developed by the Dictaphone Corporation in America. Applicable to any type of operation in which the worker normally follows a drawing or written instructions, the Audio Instructed Manufacturing Operation, as it is called (AIMO for short), uses a tiny receiver attached to the worker's belt, with a listening device leading to the ear. Oral instructions for step-by-step operations in any assembly or other manufacturing process are recorded by an instructor, and a modified tape machine is used to transmit the record to the operator's receiver.

As most people can only retain limited amounts of information at a time, the oral instructions are divided into logical units, and the production worker can control the playback by means of hydraulic tubes laid along the shop floor. Stepping on one tube causes the machine to transmit a " block " of instructions, and then pause to allow the work to be done. When the instructions have been carried out, the worker signals the machine to transmit the next unit in the operational sequence. If the instructions are not understood, or the worker wishes to check a detail he has only to step on a second control tube and the machine will back space and repeat the last block of instructions.

AIMO has been tested under normal production conditions in the United States, and it is claimed to be particularly suitable for use in some branches of the electrical industry, where workers with little or no formal training can follow intricate wiring procedures. The system is being studied by the Dictaphone Company Limited, for possible use in this country, but no date has been given for its introduction here.

Operation and Maintenance

GETTING THE MOST OUT OF BRITANNIA AIRCRAFT

To help airline operators to get the best possible performance from their Britannias, Bristol Aircraft Limited, Filton House, Bristol, have set up a department charged with the investigation of individual operating problems. Known as Operations Development, the department specialises in close cooperation with Britannia users, with the object of securing for them the most advanced performance possible.

Airline operating costs can be based largely on the hourly cost of keeping the aircraft in the air. If the time taken to do a particular job can be reduced, it follows that the cost of operation will be cut. In the case of the Britannia a saving of as little as 1 per cent a year in flying time can reduce operating costs by over £10,000 for a single aircraft, and it has been estimated that by making full use of new operating procedures devised by Operations Development, savings of up to 10 per cent can be effected.

The type of work done by Operations Development is exemplified by an investigation carried out for Canadian Pacific Airlines. Last summer CPA were about to start using Britannias on their 5,000 mile trans-Pacific route between Vancouver and Tokio, flying westbound nonstop against the prevailing winds. A navigational problem arose because the unpredictability of the abnormally strong headwinds is such that a flight plan made before the aircraft took off would often become unserviceable shortly after departure, and a complete new set of calculations would have to be made en route.

Such calculations, though normally necessary on most long range flights, may take anything up to three-quarters of an hour to complete, and this would mean flying longer than necessary at a speed and height which may not be the most suitable under the prevailing conditions. CPA wanted a procedure by which the altitude and speed could be worked out at frequent intervals during a long flight, the calculation time not exceeding two or three minutes. In addition, CPA asked for the answer to a question which, for turbine aircraft, had never before been worked out. This was the question of whether it would be better, bearing in mind that the strength of the headwind usually increases with height, to climb into a stronger headwind and get better engine performance, or to descend into a lower headwind and suffer an increase in fuel consumption. Previously there had only been one answer to this question: " try it and see."

The Bristol team was sent to Canada, to work with CPA and find a solution to the problem. Their investigation made it possible to produce a single sheet of Perspex-covered card on which is printed a set of coloured charts giving the navigational information necessary. By referring to the chart the navigator can now compress his former 45 minutes' task into less than 30 seconds. Now, no matter how often weather conditions change during a flight, the crew can determine, in a matter of seconds, the most efficient way of operating the aircraft, thus saving time in the air. The operating charts are now being developed into a simple pocket computer, which will do the job even quicker.

FASTER TURN ROUND FOR LORRIES

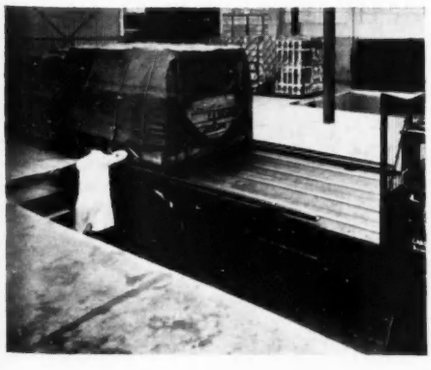
The Cargon transport system, introduced by Cargon Transport (GB) Limited, Bordesley Works, Birmingham 12, is based on a mobile deck, which can be moved on to or off a vehicle in a matter of seconds. Built-in clamps enable the Cargon deck to be secured to the vehicle with the aid of a simple hand brace, and the total turn round time, from arrival to collect a load until departure loaded, is only a few minutes. Cargons are built to standard vehicle sizes and are suitable for use with any normal commercial vehicle with a flat floor. Very little adaptation is necessary on the vehicle. Four flat rails and two guide rails bolted to the deck take the weight of the Cargon and guide it as it is rolled on or off.

The Cargon itself is a fabricated steel platform, with 12 specially designed wheels running on sealed roller bearings. It is normally made as a simple, flat platform on which goods can be stacked, but other versions are available; a lightweight box body can be supplied for handling food products, for example. With loads up to 3 tons the Cargon can be pushed on or off the vehicle by one man, but for heavier loads a hand operated winch is mounted on the vehicle and a wire cable is used to pull the container in either direction as required.

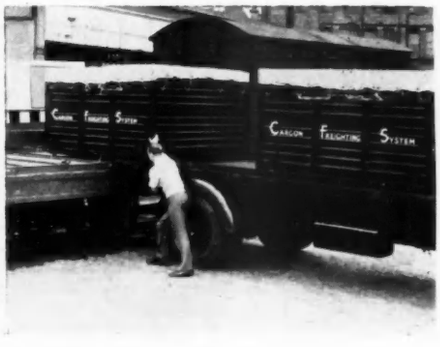
A normal method of using the equipment would be to have a number of Cargons, which were being loaded in the factory or warehouse while a suitably equipped lorry was out making deliveries. As soon as it was empty, the lorry would return to the loading point, leave its empty Cargon and take away a loaded one. If several different types or makes of lorry are in use, with different deck heights, a short bridge can be provided to allow for the difference.

Transfer from one type of vehicle to another is equally simple, provided that each vehicle is equipped with the Cargon rails. A lorry can unload to a railway wagon, for example, or vice versa, or the Cargon can be loaded into a freight aircraft.

A loaded Cargon platform can be moved on or off the vehicle by one man.



Transfer from one type of vehicle to another is equally easy.



Marketing

Outposts in Europe

The coming into existence of the Common Market and the consequent shelving of Britain's Free Trade Area proposals does not seem to have had very much impact on the plans of British companies interested in European trade. Most people actively concerned seem to look upon the present situation as a stage on the road to a free trade area and are acting accordingly. The recent appointment of an European resident technical representative by Marconi Instruments is an example of this attitude. The man in this new post, Mr. Robert L. Cogdale, will be based near Paris—in the heart of FTA opposition. The objects of the appointment are stated to be " greater coordination of sales activities in the area " and, in particular, " to reinforce the company's position in the countries forming the European Common Market." Mr. Cogdale, who has considerable technical knowledge and experience of the firm's products will assist the company's agents in the telecommunications, industrial, medical and nuclear fields.

Perkins Engines Limited have reorganised their European export organisation into two separate zones, each with a manager experienced in selling in European markets. The West European zone, comprising Italy, France, West Germany, the Benelux countries, Austria, Switzerland and Algeria, will be managed by Mr. Edward Bartlett who is 38 and joined Perkins in 1951. The other, East European zone, consists of Scandinavia, Yugoslavia, East Germany, Poland, Bulgaria, Rumania, Hungary, Czechoslovakia, Iceland, the USSR and also Israel. The new manager, who is only 29, is Mr. Frank Wilkinson. He joined Perkins in 1953 and has since travelled many thousands of miles throughout Europe for the company as a senior representative in the export department. Both men are Cambridge graduates.

The third appointment of this type was made by Siemens Edison Swan who have created the post of overseas technical representative, radio division, based on the company's Charing Cross Road office. He is Mr. M. Carpenter, whose task will be " to promote overseas sales of the company's cathode ray tubes, valves, semiconductors and other components for industrial and domestic equipment, mainly in the Western European market."

Revolution in Retailing

The changes everyone is aware of, which are taking place in the retailing of food, stationery and other " expendible " consumer goods are paralleled by similar changes just as radical in the channels through which goods travel from the manufacturer to the consumer in the ironmongery and hardware trade. In an address to the Diamond Jubilee Conference of the National Federation of Ironmongers (held at Harrogate last month), entitled " The Distributive Thaw," Mr. Nicholas A. H. Stacey, put forward what he called " a modest proposal for new thinking in the hardware trade."

Mr. Stacey said that " better shops, superior service, low cost retailing and light standards " will be demanded from shopkeepers in the future and that these improvements would have to be achieved without extra margins, save for bulk buying. He pointed out that from 1950 to 1957 the number of ironmongery and hardware shops declined by 5 per cent, although their turnover rose by 47·2 per cent and they employed 7 per cent more people. Despite such seemingly satisfactory figures their number declined from 41 per cent of the total of household goods shops in 1950 to 39 per cent in 1957 and the share of turnover fell from 26 to 24·7 per cent.

To counter this relative loss of business Mr. Stacey advocates that independent shops should make more use of cooperative arrangements, including the initiation by the Federation of economic and marketing research. Suggesting that ironmongers should scrutinise their buying

arrangements and stock control methods, eliminate slow moving lines and improve their services to the customer, he told them that they would "attain little by talking about margins" and declaring "loftily that your shop is a reflection of the manufacturers' price and discount facilities."

The Bamboo Curtain

"The channels of trade," said the Earl of Verulam, "have the overwhelming advantage over all other forms of communication in that they leave something tangible behind them." He was addressing the Royal Society of Arts and his subject was China. The paper he read, entitled "Trade and the Bamboo Curtain," was his assessment of the nature and potential of the market for British goods offered by Communist China. Lord Verulam spent only two weeks in China, in January of last year, but he is a widely travelled person, trained in the art of assessing business potentialities on very brief acquaintances with a country. His words are more convincing, and sound more realistic, than most of the many utterings on China.

Lord Verulam advocates a realistic assessment of New China and its potential as "a matter of real moment to Britain and the West." He points out that Russian achievement is valued more highly than Western words, and that the Chinese, with the oldest continuous major civilisation behind them, are not interested in European culture as such. His paper is a live and most absorbing review of what is taking place in China, and of that country's actions and aspirations. If the countries of the West are to stake a claim in what is likely to develop into a vast market for Western products, and if they are to provide an alternative to Russian influence, they will have to put forward something really imaginative. Lord Verulam suggests an offer to undertake, over the next 20 years, the provision of designs and the equipment for the correction of the Yangtze-Kiang, with its locks barrages, hydro-electric schemes and measures for flood-prevention. "The Government of China," he said, "could hardly refuse such an offer . . . which would by its sheer magnitude strike home more forcibly, and more permanently, in a language that all could understand."

GEC Reorganise Sales

A major reorganisation of their London sales area has been undertaken by the General Electric Company, aimed at decentralisation in order to "establish a closer relationship with customers and to cope with the growth of the business." The first stage of the plan, announced recently, has been the establishment of a new sales and distribution area office at Magnet House, Hanger Lane, Ealing. This will cover the North London, Eastern and Southern Counties Area including the existing GEC branches at Ipswich, Dagenham, Luton, Reading, Southampton and Bournemouth.

The next stage will be the establishment of a new area office in South London to cover the territory south and south-east of Central London. The Central London office will be established in Magnet House, Kingsway. The manager of the new office at Hanger Lane is Mr. D. E. Kidner, formerly manager of the company's Southampton and Plymouth branches. Under him will be ten departmental managers, each responsible for a product group. The assistant manager is Mr. S. C. Sutton.

At Home

HEARING AND TALKING

In May the Ministry of Health announced that a transistorised hearing aid would be available under the National Health Service replacing the model that has been standard for ten years. For the user it will mean a reduction in weight from the 1 lb 2 oz of the old valve set, to 3¼ oz for the new set complete with battery. The old name of Medresco will be retained.

Speech and hearing are two links in the chain of communication between one brain and another. A breakdown or even an impairment of either can cause considerable suffering and annoyance. There must always be a sense of loss. As a result hearing aids have been in use for many hundreds of years—probably the cupped hand held behind the ear was the first and is still the simplest. Speech aids are a newer development.

Many methods have been employed. The trumpet is an instance of sound concentration; the reverse in fact of the megaphone. As more became known of the process of hearing, the type relying on sound conduction through the bone was developed. Electricity offered another way with an amplifier in the pocket and an earpiece in the ear. The equipment has become progressively smaller, first when miniature valves were invented and then with the transistor which made really miniature equipment, like the set contained in the frame of a pair of spectacles, possible. With the change the self-consciousness of the wearer has been removed and the feeling of being different has gone.

On the left is the latest Amplivox Sonett, shown half size. The microphone and amplifier are contained in the kidney shaped piece which fits exactly behind the ear. On the right is the Bell artificial larynx which incorperates a pitch control.

It is an interesting thought that unless you can hear you can't speak properly. The fact that it is so, is demonstrated every day; simply listen to a deaf person (who is not using an aid) talking. Both volume and pitch are largely uncontrolled. A good deal of work has been done on the subject recently in this country with some intriguing results. It would seem that the control of speech involves a natural feed-back mechanism, but there are two circuits. The lower frequencies are transmitted back through the bone structure and the higher through the air so that your voice always sounds lower pitched to yourself than it does to anyone else, for they of course are dependant on the air circuit alone.

The speed with which the feed back control operates must be considerable. Consider a singer following a complete melody. First the sound has to be produced, then it has to be checked against the note of the music as heard by the singer and then corrected. Yet with the expert there is no perceptible time lag. It has been studies along these lines that have led some people to believe that all speech defects for which there are not obvious physical reasons are in fact due to hearing defects: there is some breakdown in the feed back system. For example, it is possible to imagine that stuttering is due to a delay along the line, throwing the corrections out of phase.

Speech, the other link in this communication chain, can be said to be made up of two operations. First a sound somewhat akin to a carrier wave is produced by the vibrations of the vocal cords, and second this sound is modulated by mouth, lips, tongue, or teeth to produce words. It so happens that sometimes the larynx has to be removed due to disease or accident, with the result that the patient can no longer produce intelligible speech—a terrible handicap. Some years ago a so-called artificial larynx was made which did enable the user to make reasonably intelligible speech though very "mechanical" in timbre. It had other defects and disadvantages as well.

Now a new version has been developed by the Bell Telephone Laboratories which uses transistors and gives a greatly improved speech production. Basically it consists of a transducer which is held against the throat and is vibrated electrically, in turn vibrating the throat cavity to reproduce the effect of the vocal cords. The second stage of modulation by mouth, tongue, lips, or teeth, then proceeds as normal. One great point of the new instrument is that the frequency can be varied by a finger switch as the conversation proceeds, thereby removing much of the "mechanical" effect of the sound. For men the frequency range is from 100 to 200 c/s (middle C on the piano is 250 c/s and the frequency doubles for each octave) and for women from 200 to 400 c/s, allowing for the natural differences in pitch.

This artificial larynx is still in the experimental stage and it is hoped that a more compact unit can be built using printed circuit techniques. In its present form the instrument measures 3¼ in long by 1¼ in diameter and is self contained. It was constructed using modular techniques to keep the size down. The circuit consists of a relaxation oscillator driven by two transistors with a variable resistance to give pitch control. The pulse width is determined by a feedback network. The output is a negative pulse which, as mentioned before, can be varied to alter the pitch.

A third transistor acts as a single ended output stage to feed the transducer, which is a standard telephone receiver. A diode isolates the multivibrator from the power amplifier input impedance during the period between pulses. Power is supplied by two 5·2 V mercury batteries connected in series which will give continuous operation for 12 hours, equivalent to several days of normal use.

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